The Blast Furnace and Steel Plant

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The Blast Furnace and Steel Plant

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PIONEERS

THEODORE ROOSEVELT remarked that as long as the spirit of the Pioneers actuated the deeds of the people of the United States they need have no apprehension as to the country's future. He refers to those Pioneers who pushed the border line farther and farther west; who "blazed a trail" through the forest that those following might find an open path; who were too ambitious to remain satisfied with tasks when accomplished, but pushed constantly forward. These are the men who implanted, in the blood of Americans, a spirit that has made them a power.

Like these were the Pioneers in the steel industry. In the early days of that industry it required perseverance and fortitude, of a high degree, to combat and overcome the reverses and discouragements continually arising.

Men possessed of these characteristics in the development of the open hearth process were S. T. Wellman, Horace Lash, H. H. Campbell and others. The name of John Fritz is intimately linked with the perfecting of the three high mill, while C. H. Morgan and William Garrett surmounted inconceivable obstacles to make the continuous mill a reality. The blast furnace was brought to its present day proportions largely through the labors of men like David Thomas, Captain "Bill" Jones and Julian Kennedy. The Bessemer process might have been known as the Kelly process had the efforts of William Kelly been recognized as they deserved to be. Other names which must be given recognition as pioneers are Alexander Holley, of Troy, who labored incessantly to improve the art of rolling shapes; Thomas J. Bray, long identified with the pipe and tube industry, Robert Hunt and many others.

These men turned over their tools for a later generation to refine and perfect, but it was they who pioneered the work. Laboring with equipment crude and inaccurate, they "blazed a trail" that others might follow with greater assurance.

Iron Ore in Mexico and Central America

Operation of Mexico's One Steel Plant Affected by Politics—Steel Consumption Tabulated—Extent and Analysis of Ore Deposits in Mexico and Central America

By **OLIN R. KUHN***

MEXICO and Central America have never been important as producers of iron ore and pig iron although in the future these countries, especially Mexico, will probably become an exporter of iron ore if they do not consume it themselves.

MEXICO

Several large deposits of high grade iron ore are known to occur in Mexico, but up to the present time there has been little development. The fuel and industrial conditions in the Mexican interior are likely to restrict the local iron industry to relatively small size and while the iron ore deposits so far known do not promise any enormous tonnage, it is known that there are ore deposits in all parts of Mexico, although for some years only the areas near the coast are likely to be developed. The iron ore reserves of Mexico are considerably in excess of her present requirements which are confined to one furnace at Durango belonging to the Monterey Iron & Steel Company.

This is practically the only iron and steel company in Mexico and was organized in 1900 although because of the vicissitudes of the political life of Mexico it has never reached its productive capacity of 150,000 tons of steel annually. Since this plant was built it has only operated intermittently and several changes and additions were made between 1910 and 1913 which improved the operation although the plant has never operated at more than one third its capacity.

MONTEREY IRON & STEEL COMPANY

1–300-ton blast furnace, 100,000 tons annually,
120–Beehive coke ovens,
1–15-ton Bessemer converter,
4–35-ton open hearths,
1–40-inch roughing mill,
4–Rolling mills, 32 inch, 28 inch, 18 inch and 12 inch,
Foundry with three cupolas,
Ore mines—Durango and Golondrinas,
Limestone, coal, fluorspar, and manganese ore properties controlled and located not far from the plant.

Mexico consumes about 250,000 tons of steel annually although during the last 12 years the consumption has averaged less than 100,000 ton annually.

MEXICAN IRON AND STEEL IMPORTS

Peaceful Years

Year	Imports	Production	Consumption
1903	168,900	9.900	178.800
1904	139.400	23.400	162.800
1905	184.100	19,700	203.800
1906	210.700	31.100	241.800
1907	230.400	23.100	253.500
1908	185.000	23.600	208.600
1909	161.400	48.700	210.100
1910	208.200	54.700	262.900
1911	161.500	64.000	225.500
1912	171,400	57,800	229,200
Revolutionary Years			
1913	5,000	12,800	17,800
1914			
1915	14,600	1,700	16,300
1916	33,100	20,000	53,100
1917	34,900	19,100	54,000
1918	31,300	25,900	57,200
1919	99,600	30,900	130,500
1920	105,900	26,000	131,900
1921	99,200	34,100	133,300
1922	95,700	41,600	137,300

The principal iron ore deposits in Mexico that have been worked or studied to some extent are:

Cerro del Mercado, near Durango in the State of Durango.

Las Truchas, near the mouth of the Balsos River, State of Michoacan.

El Mamey, near Manzanillo in the State of Colima.

Las Vegas, near Vera Cruz in the State of Vera Cruz.

Carrizal, near Monterey in the State of Nuevo Leon.

Monclova, in the State of Coahuila.

Tequesquite, on the isthmus of Tehuantepec.

Cerro del Mercado

The Cerro del Mercado or Iron Mountain deposit about one mile north of Durango forms the top of a hill rising 700 feet above the surrounding plain. It consists of a mass of solid ore about one and one-third miles long by one third of a mile wide and 200 to 400 feet thick. The ore is a specular hematite, martite, or magnetite, according to the locality. As a rule it is hard and massive but at one end of the deposit it is quite powdery. Part of this deposit is owned by the Monterey Iron & Steel Company and the balance by a Boston syndicate. The ore is of very high grade and the engineers who have examined the deposit estimate that it contains about 360,000,000 tons of ore that will average 60 per cent in iron content.

IRON MOUNTAIN ORE

	Per cent
Iron	60.00 to 65.00
Silica	3.00 to 7.00
Manganese	.15 to .30
Phosphorus	.20 to .80
Sulphur	.02 to .35

Las Truchas

The Las Truchas group of iron ore deposits includes about a dozen deposits located near the mouth of the Balsas River about five miles from the coast. These deposits are composed of high grade hematite ore averaging about 64 per cent in iron and low in phosphorus. There is practically no covering on this ore and it can be removed by steam shovels. These deposists were owned by the Minas de Fierro del Pacifico, a Mexican company, but were purchased by the Midvale Steel & Ordnance Company in 1919 and now belong to the Bethlehem Steel Corporation. Actual development of these deposits has been commenced and includes the opening of the mines, the construction of a railroad to the shore, and a harbor. This property contains some 1,500 acres owned in fee and the engineers estimate that it contains 26,000,000 tons of proven ore but the probabilities are that this reserve will be closer to 60,000,000 tons. The ore from the Las Truchas deposits will probably be sent to the Bethlehem Steel Corporation's furnaces in the United States.

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*Buffalo, N. Y. October 1926.

LAS TRUCHAS ORE

	Per cent
Iron	63.92
Silica	5.98
Phosphorus	.049
Sulphur	.027
Manganese	.027
Alumina	.54
Lime	.51
Magnesia	.29
Loss	1.21
Moisture	2.00
Natural Iron	62.64

El Mamey

The El Mamey deposit is located in the State of Colima about 40 miles north east of Manzanillo and is being developed by an American company. The ore is a high grade hematite with a small quantity of magnetite and the reserve is estimated by the Imperial Mineral Resources Bureau to be about 40,000,000 tons. Both coal and limestone deposits are said to exist in the vicinity.

EL MAMEY ORE

	Per cent
Iron	68.89 to 64.15
Silica	1.30 to 8.10
Phosphorus	nil nil
Sulphur	.12 to nil
Alumina	Trace Trace
Manganese oxide	.09 to .08
Oxygen	29.46 to 27.56
Lime	Trace Trace

Las Vegas

Deposit of magnetite ore have been found at Las Vegas near Vera Cruz which are said to average about 65 per cent in metallic iron but the ore contains

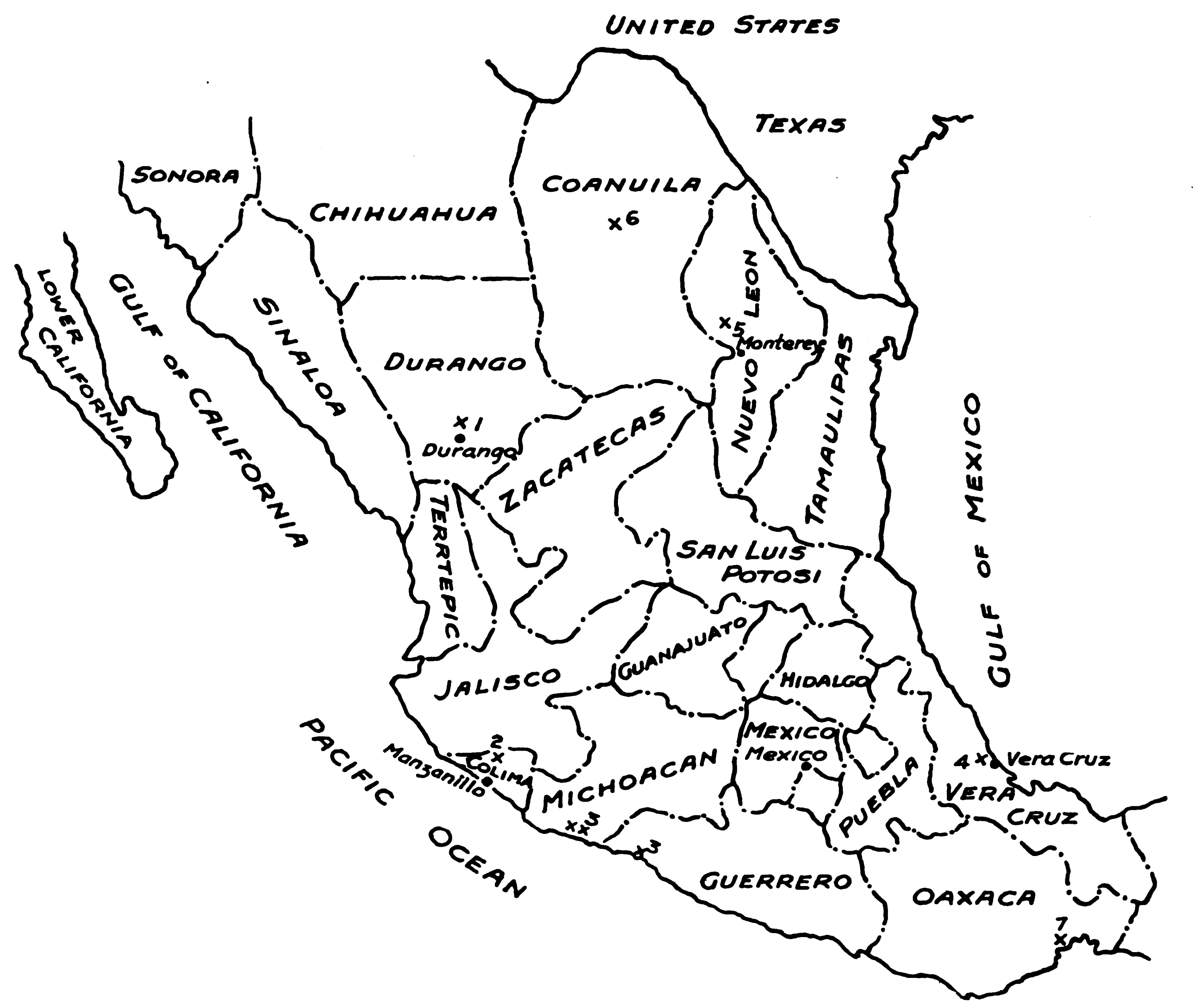

FIG. 1—Map of Mexico showing iron ore deposits.

considerable sulphur at times. There are no estimates available of the reserve in this deposit.

LAS VEGAS ORE

	Per cent
Iron	65.00
Silica	2.50
Phosphorus	.016
Sulphur	Up to 1.80

Monterey

The deposits near Monterey in the State of Nuevo Leon are worked by the Monterey Iron & Steel Company. The principal mines are on the Carrizal Mountains and the ore is a high grade hematite carrying from 55 to 65 per cent of iron, from 2.50 to 5.50 per cent of silica, and low in phosphorus and sulphur, but there is little available data on these deposits.

CARRIZAL MOUNTAIN IRON ORES

	Piedra Iman	Anillo de Hierro	Cinco de Mayo
	Per cent	Per cent	Per cent
Iron	65.76	67.35	55.20
Silica	5.41	2.42	2.90
Phosphorus	.056	.044	.022
Sulphur	Trace	Trace	Trace
Mang. Oxide	.25	.37	4.51

Monclova

At Monclova in the State of Coahuila there is a deposit of high grade hematite ore which is said to carry about 64 per cent of iron. This deposit is also controlled by the Monterey Iron & Steel Company, but there is little information as to the reserves.

MONCLOVA ORE

	Per cent
Iron	63.39
Silica	3.85
Phosphorus	.022
Sulphur	.18
Manganese oxide	.27

Tequesquite

Magnetite and hematite ores occur at Tequesquite on the isthmus of Tehuantepec which contain up to 66 per cent of iron and 5 per cent of silica, but there is no information available regarding the reserves. These deposits are said to be owned by an American company.

Varying estimates of the iron ore reserves of Mexico have been made over the last 15 years or so, but as a rule, they have been too conservative. The Geological Congress in 1910 put the reserve at 55,000,000 tons, E. C. Eckel in 1914 estimated the reserve at the same amount, while the Imperial Mineral Resources Bureau in 1922 credited Mexico with 243,000,000 tons. Since this last estimate the Monterey Iron & Steel Company have given out some figures on the iron ore reserves of that company so that an estimate of at least 500,000,000 tons of iron ore for Mexico should be fairly conservative.

IRON ORE RESERVES OF MEXICO

District	Reserve	Per cent Iron
Cerro del Mercado	360,000,000	60 to 65
Las Truches	60,000,000	60 to 65
El Mamey	40,000,000	64 to 69
Las Vegas	No Estimate	65.00
Monterey	No Estimate	55 to 68
Monclova	No Estimate	63.00
Tequesquite	No Estimate	66.00
Total	460,000,000	

CENTRAL AMERICA

Central America has no iron industry and has not been thoroughly explored although deposits of iron ore are reported from Honduras, Nicaragua, and Panama but as yet none of them have been developed.

Honduras

A deposit of high grade magnetite ore containing about 69 per cent of iron and little phosphorus or sulphur is reported to occur at Agalteca, about 50 miles northwest of Teguciglpa. Some development work has been done on this deposit and it is reported that some millions of tons have been proven. However, these deposits are some distance from the railroad and can not be exploited until it is extended to reach them.

Other deposits of iron ore are reported to occur in the district of Petoa, in the department of Santa Barbara, but there is no detailed information concerning them.

Nicaragua

Deposits of iron ore of considerable size occur in the Pis Pis district of northeastern Nicaragua. The principal deposits are found close to the Banbano River which empties into the sea about 100 miles south of Cape Gracias a' Dios and are located about 60 miles up the river.

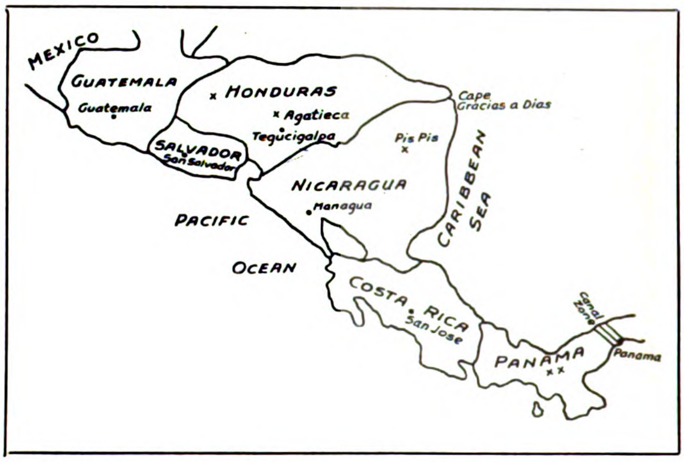

FIG. 2—Map of Central America showing iron ore deposits.

The ore bodies occur as large lenses in andesitic rocks near their contact with sedimetary rocks. The ore is reported to be low in phosphorus and to contain about 65 per cent of iron. Four of the larger ore bodies are estimated to contain at least 25,000,000 tons of ore. These deposits have never been developed.

Panama

Captain John F. Sheridan while prospecting for gold in the provinces of Chiriqui and Veraguas in 1914 located a large body of magnetite ore in the foothills of the Chorcha mountains. He states in his report that "from stripping calculations I judged this deposit to be of high grade ore and to reveal from the surface level to upper outcroppings approximately 300,000 tons, but as we sank no shafts nor did any drilling, I can not state to any degree of accuracy as to what tonnage this deposit will carry. But from the numerous outcrops of high grade ore I would judge the tonnage to be easily in the eight or nine figures."

(Continued on page 112)

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Fuel Economy in the Steel Industry*

Possibilities of Fuel Economy in Iron and Steel Industry Discussed —American and German Practice Compared—Output and Labor Saving First in American Plants

By H. A. BRASSERT†

PART II

OWING to its high inert content and low flame temperature, the blast furnace gas is most useful for heating long combustion chambers and flue systems. It gives a mild and uniform heat and a long travel of the flame. Hot blast stoves and coke ovens, the former without and the latter with regeneration, are the best examples for these requirements, and afford a very complete interchange of heat, which is particularly desirable when using a high inert gas of low heat value on account of the relatively small differential between flame and waste gas temperatures. Coke oven operators abroad who are using blast furnace gas and those in this country who use producer gas, which is nearest to blast furnace gas in heat value, have found it much easier to maintain uniform temperatures in their flue system than when using coke oven gas. The low flame temperature makes damage to brickwork less liable to occur. A very accurate temperature control is possible because of the nearly equal volume of gas and air required for combustion and because there is but little variation in the composition of blast furnace gas, especially when the same is furnished from more than one furnace.

The high inert content of the blast furnace gas also makes it the most suitable fuel for use in gas engines. This gas on the other hand should not be used under boilers where the cheapest kind of solid fuel can be used to full advantage, such as coke breeze, low grade and slack coal, or waste heat. These sources should form the basis for generation of steam power.

Possible Application of Low Temperature Coking Process

The coke residue from low temperature distillation of bituminous coals may in the future constitute an economical fuel for generating that portion of steam required over and above the amount made from unsalable blast furnace and domestic coke screenings. Wherever public power stations are connected with city gas plants—and large steel works should also be regarded as public sources of gas and power—a low temperature carbonization department would seem to have a place as it is a source of cheap fuel for power and also a producer of both gas and tar. The difficulties in commercializing low temperature carbonization in this country have been the inability to produce a metallurgical coke or even an acceptable domestic coke; briquetting is too expensive to compete with standard American fuels and there has been no market created here for the low temperature tars. However, it may develop that the special value of the gases from low temperature distillation, which is due to their richness and the fact that they can replace oil in carburetion of city gas, may be realized in connection with using the coked residue in power plants, while the tar may be useful in metallurgical furnaces in mixture with gases of low luminosity until other markets are developed.

Isolated Furnace Plants

There are, of course, a number of isolated blast furnaces in this country, principally such as are not connected with steel works, which have no outlet for their surplus gas in their own plant and for that reason must naturally use their gas under boilers for generating the power required in their own operations. Such plants should seek connections with neighboring industries and public utility companies, or in the absence of such possible connections, consider whether the cheap source of power which they hold would not warrant the development of industries of their own, principally those which use blast furnace slag.

The opposite condition generally exists in integrated steel plants where there is not enough blast furnace gas available both for heating coke ovens and metallurgical furnaces, and therefore part of the heating gas has to be generated in gas producers.

Gas Producer Practice in Steel Plants

The gas producer as generally used in the steel industry furnishes a gas of low heat value, generally between 130 and 140 Btu. It is located as close as possible to the furnace in order to retain the sensible heat which increases its calorific value slightly beyond the figures given. The saving of this heat is not so important a factor in the case of regenerative furnaces where waste heat boilers are used. In heating furnaces using unregerenated producer gas, the sensible heat is essential in increasing the flame temperature. Raw producer gas has the advantage of being the cheapest artificial gas, and the gas burns with a highly luminous flame which is an advantage in metallurgical operations. The disadvantages attached to the use of raw producer gas are that it varies in quality and the control of its combustion is difficult and uncertain, resulting in too much excess air generally being used, which causes heat losses and scaling of the steel in heating furnaces, although this is counteracted to some extent by preheating the air, less oxidation taking place when combustion is hastened. Also gas from many coals contains more sulphur than is desirable in melting steel, which sulphur can not be removed from hot gas. Because the producers must be located close to the furnace in order to conserve the sensible heat, producer installations become scattered, rendering their supervision and operation more difficult and making it necessary to deliver the coal and steam to many points, conditions which naturally involve a higher cost than would be attained with a large central plant. Losses of heat and excessive labor cost incident to the removal of ashes and clinkers has been largely eliminated by the installation of mechanical producers, but gas flues and checkers become

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*Paper presented at the International Conference on Bituminous Coal, Pittsburgh, November 15 to 18, 1926.

†Consulting Engineer, Chicago, Ill.

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clogged with soot, affecting their efficiency. In order to get the best results, a high grade coal has to be purchased, usually screened coal with a low sulphur content. The use of blast furnace gas for heating steel obviates these disadvantages.

Unmixed Blast Furnace Gas

By preheating the air or blast furnace gas or both to various degrees, the flame temperature can be raised in accordance with the demands of the heating process to which it is applied. But it must be borne in mind that actual flame temperatures are always considerably below the theoretical temperatures. Unmixed blast furnace gas is used widely for soaking pits and heating furnaces in Germany, to some extent in England and in one American plant. In many cases it is preferred to producer gas and has the advantage over coke oven gas of giving a milder, longer and heavier flame which can be more easily controlled and regulated to its theoretical air requirement, so that less oxidation of the surface of the steel takes place and less scale is produced. The author was impressed with the excellent heating in Germany with preheated or regenerated blast furnace gas. Finely cleaned blast furnace gas is preferred there to producer gas because it keeps the checkers clean and increases the life of the furnace. The excellent preheaters which have recently been put on the market in this country offer the opportunity of preheating both air and gas at a very low cost where the highest temperatures are not required or before admitting them to the checkers. In the development of air heaters with metal sheet heating elements, it is possible with gas temperatures of 1800 deg. F. to preheat the air required for combustion to 1500 deg. F In the past there has been a great loss of heat in steel plants due to inefficient heat regeneration. In the average heating furnace the temperature of the air has probably not been above 700 deg. F. with waste gases of 1500 deg.

Enriched Blast Furnace Gas

For melting steel in the open hearth furnace, blast furnace gas has too low a heat value and is too high in nitrogen. For this and other high temperature work it must be enriched. This can be done either by mixing a certain amount of coke oven gas, tar or oil with it or by passing it through a producer.

At many works abroad and at one plant in this country, blast furnace gas and coke oven gas are mixed together, and in the case of open hearth furnaces some oil or tar is usually added. The general practice is to maintain the Btu. content in the mixture within the range where the gas does not have to be regenerated. This mixed gas then is available for all purposes throughout the steel works and rolling mills and also for coke ovens equipped for air regeneration only. On the other hand it would seem that greater economy can be reached by using each gas separately, applying them where they give the best results and where the largest returns can be made. In cases where all of the coke oven gas can be sold to communities or other industries, it would certainly seem that unmixed blast furnace gas should be used wherever feasible.

Enriching Blast Furnace Gas

The other method of enriching blast furnace gas is by passing it through the fire bed of a producer or water gas generator. With the usual types of producer, this can not be done continuously on account of clinkering. Mr. G. R. McDermott read a paper in May, 1925, before the Association of Iron and Steel Electrical Engineers on the subject of blowing gas producers with blast furnace gas, in which he gave the results attained by alternately blowing air and blast furnace gas up through a hand poked producer. He attained, using coal, a Btu. value of 195.2 when blowing with gas, as against 121 when blowing with air, the average gas during the tests of four hours containing 147.3 Btu. As these results are of the greatest interest, the analysis of the resultant gas in each case and of the mixture are herewith given.

	Combined Gas	Gas Blow period	Air Blow period
	%	%	%
CO_2	4.7	3.3	6.0
C_2H_4	.7	1.0	.5
H_2	7.2	10.2	6.0
CO	29.6	35.4	23.4
CH_4	2.4	4.2	2.4
Btu. low value	147.3	195.2	121.0

Mr. McDermott has made a decided step in the direction of improving producer practice by the use of blast furnace gas in place of steam. The combined gas is realtively high in CO and low in H and water vapor, both of which are undesirable in open hearth and heating practice if present in too high a percentage. Mr. Waldemar Dyrssen also has pointed out the advantage of the use of either waste gases or blast furnace gases in producers with the same end in view.

A few years ago the author caused the experiment to be made at the Federal Furnaces at Chicago, of passing raw and also washed blast furnace gas up through a generator filled with small coke which was heated by down blasting the coke. The average analysis of the resulting gas was as follows:

	Raw Gas	Enriched Gas
	%	%
CO_2	12.0	3.0
H_2	3.0	12.0
CO	27.0	41.0
CH_4	.....	.2
N_2	58.0	43.8
Total	100.0	100.0
Btu.	98.8	169.0

This as well as the enrichment with coal is an intermittent operation, requiring either a holder or preferably two or more machines operating in proper sequence to give a gas of uniform heat value. In case higher Btu. values are required, the following method seems feasible. The cycle starts by blasting with air as in water gas practice and burning the blast gases in a suitable regenerator through which both the latent and sensible heat of the gases of the blast period are recovered. The blast furnace gas admitted at the bottom of the regenerator will carry this stored heat back to the fire bed by entering he producer at the top, flowing downward through the fuel bed completing the regenerative cycle by giving up its sensible heat to the fuel and ash bed. The development of the metallic heat interchangers would appear to make this method simple and efficient. Another method which suggests itself is the regeneration of the blast gases in the second generator. The theoretical calculation of the heat balance of this process shows a heat value in the finished gas of approximately 170 Btus., as corroborated by the experiment. This method seems particularly adapted to utilize the undersized coke which should be screened out of the blast furnace fuel.

Cleaning of Blast Furnace Gas

It was expected that in passing raw hot gas through an incandescent coke bed, the impurities in the gas would be eliminated through fusion with the coke ash. The results verified this expectation and indicated that a commercial method of cleaning blast furnace gas and at the same time enriching it might be developed by this method. The self-cleaning water gas generator, which has recently been developed, would seem to offer a suitable apparatus for carrying out this process as it promises to permit of higher temperatures being carried in its fire bed. The economic feasibility of the process will depend on a supply of cheap fuel, being available such as undersized coke and coke screenings.

Advantages of Enriched Blast Furnace Gas

The advantage of enriched blast furnace gas as compared to ordinary producer gas is its greater calorific value, lower nitrogen content and the lower sulphur in the gas. Its composition gives excellent qualities for heating and melting, and a utilization of blast furnace gas in this manner which would certainly seem to be more economical than burning it under boilers.

The Cycle Method of Gas Making

The cycle method of operation which is needed to produce gas with a high heat value has not been favored in the iron and steel industry, on account of complications, expense and generally unsatisfactory operation. These objections are largely based on the necessity of having a number of hand operated valves and also on account of the unavoidable shutting down approximately twice a day for clinkering. The output diminishes as clinkers accumulate. This work is of the roughest character, expensive, and the labor increasingly difficult to secure. The formation of clinker prevents the complete gasification of the fuel and thus leads to an appreciable loss of carbon. But these difficulties have been completely overcome by the introduction of automatic, mechanical valve operation and the continuous generator. With the self-cleaning grate this generator has been successfully operated with both coke and coal as fuel, showing a very large capacity compared to existing gas producing machines. The demonstrated capacity of a 9 foot inside diameter machine operated as a water gas generator using coke, is 120,000 lbs. per day.

Gasification of Carbon by Blast Furnace Gas

The valuable papers by Fred Clements (British Iron and Steel Institute, 1923) on gas producer practice, and Waldemar Dyrssen (1923 Year Book, American Iron and Steel Institute), and discussions of the latter paper by Chapman and Siebert gave a great deal of information on the subject of gas making. Mr. Dyrssen has established an equilibrium diagram for the system C, H_2O, H_2, CO and CO_2 at various temperatures of gasification from which he has determined heat and chemical balances for C gasified by the various gases. He calculated the theoretical efficiency of the gasification of C by blast furnace gas as 76.4 per cent, and the heat in blast furnace gas in per cent of total heat used as 17.7 per cent. Mr. Siebert has pointed out that Dyrssen's assumptions were not necessarily correct as far as actual practice is concerned on account of the absence of horizontal zones of approximately equal temperature. This condition should be added to the requirements of a perfect generator or producer and it would seem that the new self cleaning generator would come nearer accomplishing this function than any other gas making machine.

Radiation of Gases at High Temperatures

The extensive investigations which have been carried on by the heat ecenomy bureau at Duesseldorf and particularly by Dr. Lent, dealing with the subject of heat transmission from metallurgical gases, have already resulted in a better understanding of the phenomena of heat transmission of such gases at high temperatures. The transfer of heat from gases to solid or liquid matter, has been treated in its four phases, viz., conduction, convection, radiation by gases and radiation by soot and vapors. Dr. Shack succeeded in calculating the radiation and absorption of heat by such gases and he proved thereby—and his theories were upheld by laboratory tests—that it is the CO_2, CO, H_2O, and light and heavy hydro-carbon constituents of the flame, which at the higher temperatures increasingly perform the function of heat radiation and absorption, whereas oxygen and nitrogen remain inert, as far as these functions are concerned. Dr. Lent proved the correctness of Schack's theory and calculations by actual tests which were made on a large scale at the Rheinstahl Works.

These investigations show that temperature is the vital factor in influencing the radiation of these gases, while the thickness of the gas body or flame passing over the bath, its concentration and the time element are of secondary influence. The radiation from soot and vapor probably takes place in accordance with the laws of radiation from one solid body to another which is as the fourth power of the difference of their absolute temperatures. The work of Dr. Lent and his collaborators proves the great value of a gas low in nitrogen and of combustion with a low amount of excess air and of a luminous flame. It also explains why a high flame temperature results in a low stack temperature and indicates interesting possibilities for raising the efficiency of the open hearth process by increasing the temperature head. The consideration that only that heat available above a certain degree is effective and that an infinite amount of heat applied at or below this temperature will produce no results, leads to the conclusion that in order to increase open hearth efficiency a high temperature head is needed, obtainable only by richer gases, which will not dissociate in regeneration.

Efficiency of Open Hearth Process

The open hearth furnace at present is thermally inefficient. Fred Clements gives its thermal efficiency as 16.98 per cent without waste heat boilers. This figure is higher than some given by American open hearth plants. Kinney and McDermott in their paper read before the American Iron and Steel Institute in 1922, gave a thermal efficiency of 14.24 per cent for 1912 and 15.8 for 1922. Dr. G. Bulle gives the efficiency of the process in German plants operating on scrap as 20 to 30 per cent, on pig iron and ore as 10 to 20 per cent and of the Talbot process as 2 to 5 per cent. By recent developments higher efficiencies have been obtained through better methods of open hearth design, causing better flame control. The improvements in fuel efficiency has been coupled with larger production and longer life of the furnace. The application of waste heat boilers has recovered from 10 to 20 per cent of the total heat, 16.4 per cent according to Kinney and McDermott.

Central Gas Station Desulphurization of Gas

The advantage connected with the production in a central station and the use throughout the plant of a clean, low sulphur gas of low inert content, so concentrated or rich in heat value that the cost of distribution is not excessive, are so many that the iron and steel plants should give this serious consideration in their future program. The economical recovery of waste heat from the process, the cleaning and desulphurizing of the gas becomes practical and economical in a central plant, whereas with the present scattered units, such refinements are impossible. The removal of sulphur from coal gases may become economical in itself through the recovery of sulphur as a by-product. As an illustration of the importance of low sulphur gas, a number of plants making alloy or other special steels are now compelled to use high priced, low sulphur oils in their open hearth furnaces. This supply threatens to become more expensive. A paper dealing with the influence of sulphur in the making of steel was read by Mr. A. N. Diehl at the May and October, 1926, meetings of the American Iron and Steel Institute. These excellent papers are of great interest in this connection. All these possibilities are so far reaching and cover such a varied field of application that it is not possible in this paper to enter into a detailed discussion of them. Although every plant has its own problems to solve in respect to fuel economy, none are insurmountable. The adoption of one system or the other or one gas or the other depends merely on local factors.

The author has endeavored to show the fuels available in the steel industry can be used to the best advantage so that a better fuel economy may be attained in its plants, at the same time releasing high grade gas for sale to adjacent communities.

Ideal Fuel Program for Steel Plants

The ideal condition would appear to be the sale of all of the coal gas from high and low temperature distillation, as it is in the field of highly divided distribution and use that this high thermal gas must seek its full value. It seems an economic waste to use it in the larger furnace units of a steel plant if it can be sold to households and small industries. This program also saves all of the weekend and holiday coke oven gas and most of the blast furnace gas. Unmixed blast furnace gas should be applied to stoves, gas engines, coke ovens and heating furnaces not requiring high temperatures, and in which this sulphur free gas is of special benefit. Steam should be generated from coke breeze and low grade coal. For melting and high temperature heating of steel a special gas should be produced in a central gas plant, preferable by the cycle method of operation; in the generation of such gas, sulphur blast furnace gas and undersized coke may be used. This new gas for melting should be low in sulphur, of the highest possible heat value and still capable of regeneration without appreciable dissociation of its constituents. This gas will give higher flame temperatures than have heretofore been reached. The resulting higher head of heat will lead to better efficiency of the process and increased output and will meet the growing demand for quality steel.

Electrical Developments

Increase in the Number of Motors Is an Indication of the Trend Toward Individual Drive for the Various Stands—Tendency Toward Large Prime Movers

THE constant increase in the number of rolling mill motors is an indication of the trend toward individual drive for the various stands. This trend is also responsible for the large number of d.c. motors purchased during the year, as only approximately half of the total number were a.c. machines; in last year's list two-thirds of the motors purchased were a.c. machines. The existing capacity of General Electric motors driving rolling mills has been increased during the year by the sale of more than 100 motors totaling approximately 160,000 hp. In number of equipments, this record exceeds last year's record by more than 40 per cent, although in total horse power, last year's record has been exceeded by only slightly more than 10 per cent.

As examples of the use of individual drives, there should be mentioned the 13-stand mill which has been installed by the Illinois Steel Company at their South Chicago plant, this mill being driven by (13) motors totaling 10,500 hp. At their Gary Works a 15-stand mill will have (11) motors totaling 5,350 hp. and a 13-stand mill will have (9) motors totaling 6,500 hp., all of which are d.c. adjustable speed.

Motor Drives for Strip Mills

The production of wide thin strip steel is another rolling mill development which has resulted in the installation of high-powered mills with individual drives. An interesting example is the continuous strip sheet mill of the Columbia Steel Company at Butler, Pa. The driving motors for this mill were purchased early in the year and placed in operation in November. The first stand is a 27-inch reversing mill driven by a 5000-hp., 70/150-rpm., 900-volt d.c. reversing motor. Power for this motor is obtained from a flywheel motor-generator consisting of one 5000-hp. induction motor, one 44-ton flywheel, and two 2200-kw. generators. The remaining four stands are each driven by a 2000-hp., 200/400-rpm., 600-volt d.c. motor. Each stand is a 4-high roller bearing mill, in which the working rolls are backed up by rolls of larger diameter. This arrangement insures uniform guage of a wide strip by preventing too great springing of the rolls.

Another mill of this type will be erected by the Weirton Steel Company at Weirton, W. Va. It will be driven by three 1500-hp. induction motors, two 2000-hp. and three 2500- hp., 200/400-rpm., 600-volt d.c. machines. Power for the five d.c. motors will be obtained from two 3000-kw. synchronous motor-generators.

Continuous Rolling with Induction Motor

The Bethlehem Steel Company will install at its Sparrows Point Plant a continous rolling mill to which three different types of motors will be applied. There will be two synchronous motors, one 4000 hp., 83 rpm. and one 6500 hp., 187 rpm. There will be one induction motor with Scherbius speed regulating set rated 6700/5000/3320 hp., 500/375/250 rpm. Incidently, this is the largest Scherbius controlled rolling mill induction motor in this country. The last stand will be driven by a 2600-hp., 275/320-rpm., 600-volt d.c. motor.

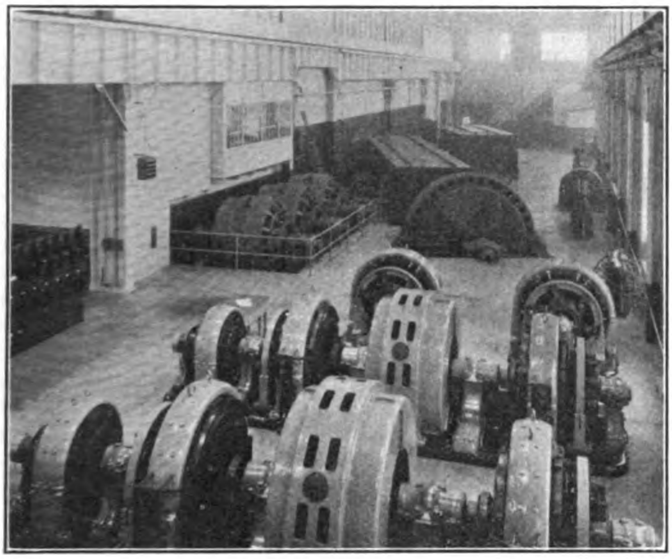

FIG. 1—Motor room, 21-in. continuous sheet bar and skelp mill, showing 7,500-hp. induction motor, three 2,000-hp. d.c. motors, three synchronous converters for Kraemer speed control and two synchronous motor generators, Youngstown Sheet & Tube Company, Indiana Harbor.

At Benwood, W. Va., the Wheeling Steel Corporation will install a skelp mill driven by four 600-volt d.c. motors, one of which is rated 500 hp., 180/360 rpm. and the remaining machines are each rated 2000 hp., 200/400 rpm.

Important equipments which have been placed in operation include a 3000-hp., 80/150-rpm. reversing motor which replaced an engine drive on a 24-inch bar mill at the Indiana Harbor plant of the Inland Steel Company. In 122 hours from the time the mill was shut down, the engine and its foundation had been removed, new foundations for the motor built, and the motor installed and connected to the mill ready for operation. This achievement lowers the previous record of change-over from steam to electric drive by about 13½ days—a commendable performance on the part of the Inland Steel Company.

Motor for Reversing Slabbing Mill

Another large reversing equipment placed in operation during the year is a double-unit d.c. motor rated 7000 hp., 50/100 rpm. which drives a 46-inch reversing slabbing mill at the Sparrows Point plant of the Bethlehem Steel Company. Power for this motor is derived from a flywheel set consisting of a 5000-hp., 375-rpm., 6600-volt induction motor, a 50-ton flywheel, and two 3000-kw., 650-volt d.c. generators. The Bethlehem Steel Company also put in operation at its Steelton plant a 3500-hp., 50/100-rpm. reversing motor which replaced a steam drive for the roughing stand of a 35-inch rail mill. The finishing stands are driven by a 4000-hp., 375-rpm. induction motor which is electrically a duplicate of the induction motor driving the flywheel set which furnishes power to the reversing mill motor.

An interesting drive which has recently been started is that on the 21-inch sheet bar and skelp mill at the Indiana Harbor plant of the Youngstown Sheet & Tube Company. The mill consists of 10 continuous stands divided into three groups. The first group consisting of three stands is driven by a 3600/-1940-hp., 290/156-rpm. induction motor with Kraemer speed control equipment. The second group consists of four stands driven by a 7500/4040-hp., 250/134-rpm. induction motor with Kraemer control. The third group consists of three finishing stands, each driven by a 2000-hp., 85/165-rpm., 600-volt d.c. motor, power for which is derived from synchronous motor generators.

Tendency Toward Large Prime Movers

Plans made during the year for the installation of large sizes of turbine generators are evidence of the tendency toward large prime movers in the steel industry. A notable example is a 30,000-kw. turbine generator to be installed by the Illinois Steel Company at its Gary Plant. This will generate at 6600 volts, 25 cycles. The Tennessee Coal, Iron & Railroad Company plans to install two 20,000-kw. generating units, and another unit of the same size will be installed by the Bethlehem Steel Company at Sparrows Point, Md.

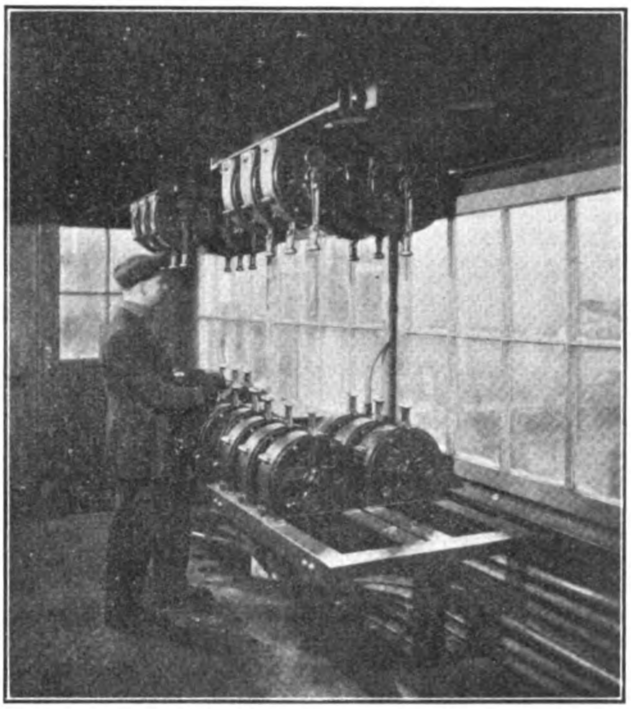

FIG. 2—The new lever operated master switch in operation.

The demand for the new M. T. (mill type) control continued heavy, and many large installations were made. Another new development in control was a lever operated master switch particularly suitable for grouping and for operation by one man.

Material Flow in the Rolling of Beams*

This Method of Determining the Flow of Metal Is Ingeneous and Novel—Effect and Magnitude of Various Forces in Rolling Beams Made Evident

By NORBERT METZ

IN order to determine the flow of metal, when being rolled, a method has been devised in which threaded test pieces are imbedded in a block of steel and this block rolled exactly as in practice. The results of these experiments were described some years ago, but more recently similar experiments have been made on beams and are here presented.

In this article, the metal flow in the rolling of beams is studied using the above method, and is carried out in two tests. First, in the "cutting in" passes of a roll designed for an N. P. 12 in seven passes on a 650 mm. roll train. Second, in the third pass of the same roll. In order to make the flow lines more distinct ingot crops, consisting of material with blowholes and pipes, were used for the investigations.

Figure 1 shows a cross section of the original stock having the following dimensions 134.5 by 106.7 mm. The position of the axes of the Whitworth screws, approximately 13 mm. in diameter (Fig. 2), which were placed into the piece, is shown diagrammatically in Fig. 1. Fig. 3 shows the diameter of the rolls and a cross section of the piece after the first pass. The upper gripping angle of the open pass is 32 deg. 31 min; while the angle of the lower closed pass is 33 deg. 10 min. The largest material flow naturally takes place in the center of the block being rolled. Fig. 4 shows a cut through the screw which was placed in the center of the original section, perpendicular to the rolling direction. The crosses in the individual figures represent the position of the other screws' axes.

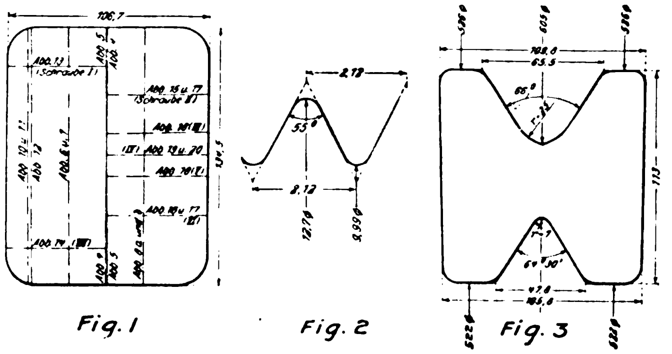

FIG. 1—Original cross section and position of the screw axes. Schraube = Screw. FIG. 2—½-in. Whitworth screw. FIG. 3—Cross section after the first pass.

The lower cutting-in angle of 64 deg. 30 min. is rounded off to a radius of 7 mm. at the point; the upper angle of 66 deg. is rounded off to 25 mm. Due to the sharp lower cutting-in angle the screw was split so that the two parts were divided on the inner surfaces of the two flanges. The top of the screw was not split by the blunt cutting-in angle, but was spread and considerably compressed.

Figure 5, shows the section, in the rolling direction, of another screw set perpendicular to the rolls. Here the lower section screw moved ahead of the upper about 11.5 mm., a natural occurance, as the reduction of the upper section is considerably greater than the lower and further it is known from the tensile stresses of the iron that the elongation in rolling takes place to a great extent in the lower part of the screw. These differences in tensile stress are due to changes of the material which are greater in the upper part of the cross section than in the lower. The cutting-in of the material always occurs on the side of the sharpest angles. Figs. 4 and 5 indicate that the reduction in the screw which is in the extreme lower part is subject to a greater compression because the pressure on the sharp lower angle points is greater than at other places. The greatest reduction of the upper part can be ascribed to the considerable material displacement by the large cutting-in angle.

Figures 6 and 9 represent the section of a perpendicular screw which was placed 32 mm. from the left side surface of the cutting-in section. Due to the material displacement caused by the cutting-in angle of the roll, the material at the inner surface is pulled along, and causes the singular curve formed at the two ends of the screw. The side pressure rises then on the cutting-in angle while the material is driven toward the web as is evident from the inclination of the points of the threads of the inner edges of the screws.

Material Displacements

The sideward material displacement between the side faces and the screw is largest on the upper flange and amounts to

$$\frac{e_1}{e_2} = 1.46 \text{ to } 1.48$$

(e_1 and e_2 = the thickness of the material before and after the pass, respectively); on the lower flange parts it amounts to 1.31 to 1.37 and is smallest in the middle of the profile web

$$\left(\frac{e_1}{e_2} = 1.10\right).$$

The sideward displacement between the screw and the inner flange sides is caused by a shearing action which can be definitely seen from the perpendicular cuts of horizontally placed screws. On the web the material is subjected to a spread, which amounts to

$$\frac{e_1}{e_2} = 0.81 \text{ to } 0.95.$$

The distance representing the movement of the horizontal screws are smaller on the horizontal line, for in addition to these sideward displacements, perpendicular movements occur, which can only be recognized on the horizontal screws.

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*Translated from Stahl und Eisen, November 16, 1927, pages 1577-1582, by Richard Rimbach, Metallurgical Engineer, Pittsburgh, Pa.

Figures 8 and 16 show the longitudinal section of another perpendicular screw which is placed a distance of 34 mm. from the right side in the original cross section. Both ends of this screw were welded electrically to the stock. The figures prove that the upper end lags behind the lower end about 18 mm., as a result of the large material displacement in the upper part. The reason for this displacement in the longitudinal direction is very important. It shows that the reduction in height, as measured between the horizontal screws, must be greater than that given by the dimensions of the screw passages. It shows, especially, that the reduction in height of the cross section is not only due to the perpendicular material displacement, but also to a longitudinal displacement.

The cutting-in pass ordinarily is filled sufficiently if

$$\frac{H_1}{H_2} = 1.07 \text{ to } 1.20$$

(H_1 and H_2 heights before and after the pass respectively). It is striking that in the segregated section

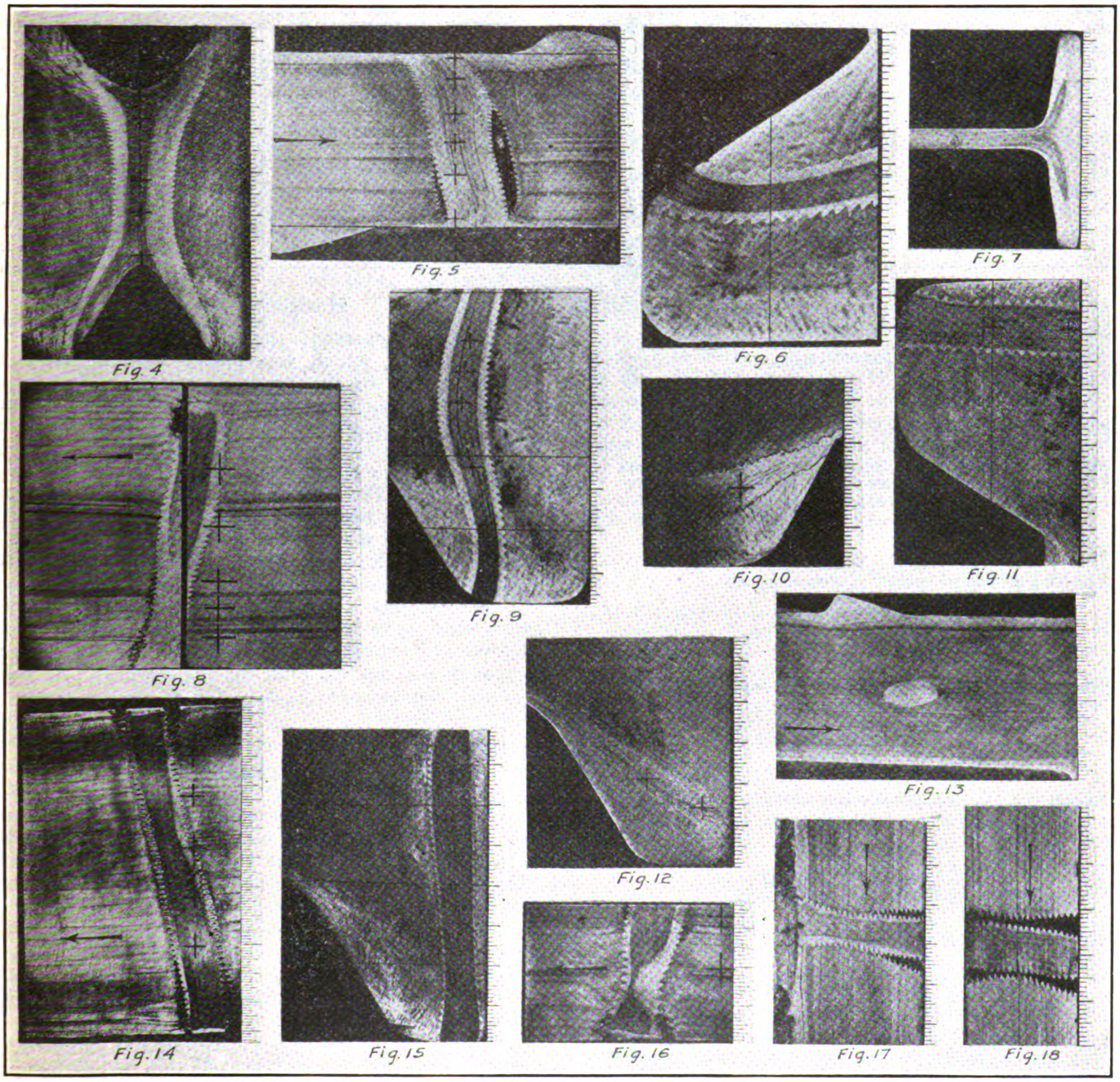

FIG. 4—Deformation of the screw in the first pass. FIG. 5—Longitudinal section through the cutting-in angle. FIG. 6—Section through a screw 32 mm. from the side edge. FIG. 7—Segregated zone of the finished beam. FIG. 8—Screw 34 mm. from the right side edge (longitudinal section). Open flange. FIG. 9—Section through a screw at a distance of 32 mm. from the side edge. FIG. 10—Horizontal Screw VII 19 mm. from the lower edge. (For clearness the threads were drawn over with ink.) FIG. 11—Same as Fig. 15. FIG. 12—Section through the horizontal Screw I. FIG. 13—Section through the center of Screw IV. FIG. 14—Screw 13 mm. from the edge of the left side (longitudinal section.) FIG. 15—Screw at a distance of 11 mm. from the left side edge. FIG. 16—Screw 34 mm. from right side edge (longitudinal section) closed flange. FIG. 17—Acceleration of the side surface, in relation to the inner surface in the closed flange (Screw VI). FIG. 18—Same as Fig. 17 (Screw VIII).

TABLE I—SIDEWARD MATERIAL DISPLACEMENT BETWEEN THE SCREWS AND SURFACE OF THE ORIGINAL SECTION

Point of Measurement	$\frac{e_1}{e_2} = \frac{\text{Thickness before}}{\text{Thickness after the pass}}$ Sideward displacement of the side surfaces up to the perpendicular screw 11 mm. from the bottom surface	$\frac{H_1}{H_2} = \frac{\text{Height before}}{\text{Height after the pass}}$ Side surfaces measured between the horizontal screws	$\frac{H_1}{H_2}$ Measured according to the passages on the vertical screw 11 mm. from side surface Fig. 12	$\frac{e_1}{e_2}$ Sideward displacement between the vertical screws	$\frac{H_1}{H_2}$ Measured on the vertical screw (32 mm. from the side surfaces) according to the screw passages	$\frac{e_1}{e_2}$ Sideward displacement between the vertical screws (32 mm. from the side surface) and the pass width
Surface	1.69	.....	.....	1.65	.....	....
Surface—						
Screw 1—(Fig. 1)....	1.76 (1.32)	1.54	1.16	1.35 (1.28)	0.855	0.653 (0.748)
Screw 1 — Screw II (Fig. 13 and Fig. 15)..	1.60 (1.26)	0.93	1.02	1.17 (1.116)	1.19	0.72 (0.71)
Screw II—Screw III (Fig. 15 and Fig. 18)..	1.37 (1.20)	1.235	1.115	1.06 (1.06)	1.32	0.81 (0.81)
Screw III—Screw IV (Fig. 18 and Fig. 19)..	1.31 (1.11)	1.21	1.205	1.01 (1.01)	1.415	0.855 (0.87)
Screw IV—Screw V (Fig. 19 and Fig. 18)..	1.29 (1.10)	1.47	1.245	1.005 (1.004)	1.415	0.868 (0.91)
Screw V—Screw VI (Fig. 18 and Fig. 16)..	1.30 (1.21)	1.11	1.15	1.14 (1.20)	.....	0.775 (0.86)
Screw VI—Screw VII (Fig. 16 and Fig. 14)..	1.417 (1.26)	1.21	1.12	1.35 (1.34)	1.23	(0.89)
Screw VII — Surface (Fig. 14)	1.84	1.055	1.095	1.13	0.94	....

of the finished beam (see Fig. 7), the screws in Figs. 6 and 9 assume the form of a root.

Figures 15 and 11 represent the section of a screw placed at a distance of 11 mm. from the left side of the original section. The largest reduction is to be expected in the lower screws in the center of the cross section. The sideward displacement between the edge of the screw is largest in the upper flange parts

$$\frac{e_1}{e_2} = 1.76.$$

In the lower flange parts it amounts to

$$\frac{e_1}{e_2} = 1.41$$

and is smallest in the center of the web with

$$\frac{e_1}{e_2} = 1.37 \text{ to } 1.31.$$

Between the two perpendicular screws there is a sideward displacement, on both flanges, of almost equal extent with

$$\frac{e_1}{e_2} = 1.37 \text{ to } 1.31;$$

while in the web it only amounts to

$$\frac{e_1}{e_2} = 1.06 \text{ to } 1.00.$$

Figure 14 shows the section of a screw which was placed 13 mm. from the left side of the original surface. The upper end is about 9 mm. behind the lower end. The tensile stresses are very large on both sides which can be noticed from the fact that the electric weld has loosed itself from the material. The larger tensile stress can be seen on the upper end. Although these facts are of great importance, the deformation of the screws set in in the horizontal direction are still more interesting.

Horizontal Screw

Figure 12 represents the section through a horizontal screw (I), which was placed 20 mm. from the upper surface in the original section. The section through the horizontal screw (VIII) placed 19 mm. from the lower surface is shown in Fig. 10. If we consider these two screws, we see that the extreme end of the lower screw is slightly bent, while the upper screw is not. The friction from the collars on the side surface of the section is larger, and the material is pushed toward the opening in the pass. The material flow toward the web of the inner flange is greater in the upper flange than in the lower as the particles of material are cut by the sharp cutting-in angle. It is still to be remembered that the centers of the screws are behind their ends about 7.7 mm. for the upper and about 7.0 mm. for the lower. The longitudinal displacement is also larger in the center of the cross section.

Figure 35 shows the section of a screw (II) which was placed a distance of 35 mm. from the upper surface of the original section.

Figure 33 shows the section of another screw (VI) at a distance of 36 mm. from the lower surface. This screw has a similar shape to that of the first. The center of the screw is behind the ends about 7 mm. for the upper and about 9.5 mm. for the lower.

Figure 34 is a section through the center of the two screws (II and VI) and shows that the change in shape of the upper screw is greater than in the lower, from which fact it is apparent that this part of the web is considerably elongated.

Figure 38 shows a section through the axes of the two screws; the upper (III) is 55 mm. from the upper surface, while the lower (V) is 56.5 mm.

Due to the friction between the sides of the roll passes and the side-surface of the piece being rolled, the ends of the screws have moved toward the pass opening. Fig. 36 which is the section through the axes of a screw (IV) shows the same shape. Fig. 13 shows the cross section through the same screw. If we compare the perpendicular material displacement of the different horizontal screws, we obtain the values shown in Table I.

Sideward Displacement

Here are shown, also, the sideward displacements between the screws and surfaces of the section. The figures in parenthesis were measured to the horizontal screws from the screw passages, while the other figures give the displacements between the perpendicular screws. From this we note that the highest perpendicular displacement of the side surfaces is on the upper edge of the open flange; a natural occurrence, as the material is forced toward that point by the friction of the side surfaces of the pass in the rolls.

An unexplained occurrence is the increase in height between screws (I and II) which can be seen on the side surfaces; this is checked by the dimensions of the passage of the perpendicular screws, which were set in 11 mm. from the side surfaces. It is possible that the cutting-in angle of the steel presses more heavily on the pass side surfaces than in any other. There arises, due to the movement of the roll, considerable friction from below to above, which deformation causes tensile stress. This stress disappears due to the flange at the end of the upper pass pressing on the upper edge of the section, but only in part between the screws I and II. On the lower part of the upper flange a greater reduction is noticeable, which can be ascribed to the pressure between the web and flange. A similar appearance is noticeable between screws V and VI, in which case, though, only a slight dimunition of the perpendicular displacement can be seen.

From this experiment the following important conclusions can be drawn: First, the friction of the cutting angle on the stock increases with the widening of the angle and corresponding to this there follows a reduction in the amount of the flange accelerations. Second, the flange accelerations increase with the height of the original section. Third, the size of the accelerations of the flanges increase if the cutting-in of the original sections is done in several passes. Fourth, to fill the cutting-in pass the following relations

$$\frac{\text{Height of original section}}{\text{Height of flange of first pass}}$$

must amount to 1.07 and 1.21. Fifth, cutting-in angles, which are too small cause a laying bare of the segregations. Sixth, the segregation which can be seen in the finished beam was already formed in the cutting-in pass.

Figures 19 and 20 give the before and after rolling cross sections, Fig. 21 the main dimensions of the 9.5 mm. Whitworth screws, which were threaded into the piece to be rolled. If one considers these cross sections, one sees that the points at which the upper roll touches the beam are on the inner side of the upper flange at a distance of about 17 mm. from the upper edge. The edges of the lower flange of the beam touch the lower roll at a distance of 57 mm. from the lower edge of the pass. The gripping angle at these points amounts to about 33 deg. 10 min. for the upper roll, and 30 deg. 22 min. for the lower roll. Due to the rolling pressure the beam is pressed in the closed pass, until the inner sides of the flange touch themselves.

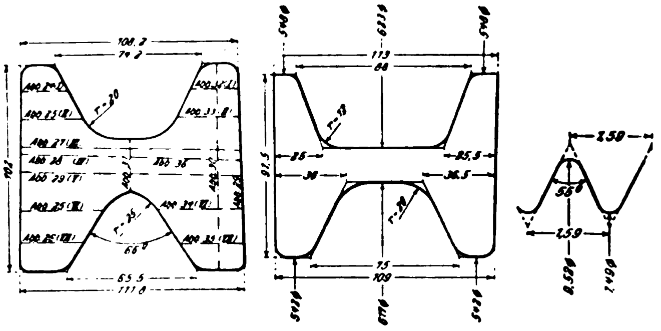

Fig. 19 Fig. 20 Fig. 21

FIG. 19—Exit cross section for the third pass in a 650 mm. roll and position of the screw axes. Abb = Fig. FIG. 20—Final cross section in the third pass. FIG. 21—⅜-in. Whitworth screw.

From this point the real rolling work of the flanges begin; the gripping angles are 21 deg. 13 min. for the upper and 21 deg. 18 min. for the lower roll. The

TABLE II—MOVEMENT OF THE STOCK IN VERTICAL DIRECTION

Point of Measurement	$\frac{H_1}{H_2}$ Measured at the outer surfaces	$\frac{H_1}{H_2}$ Measured according to the horizontal screws in the axis of the vertical screw	$\frac{e_1}{e_2}$ Measured on the horizontal screws			
Upper edge of flange— Screw I—(Fig. 24).......	1.707	1.455			1.398	Average
Screw I — Screw II (Fig. 24 and Fig. 25)..	1.219	1.007	Screw II		1.514	Average
				Edge	Vertical Screw	Web
Screw II — Screw III Fig. 25 and Fig. 27a)..	.....	1.007	Screw III	1.18	1.35	0.79
Screw III — Screw IV (Fig. 27a and Fig. 27)..	.....	1.115	Screw IV	1.225	1.18	0.70
Screw IV — Screw V (Fig. 27 and Fig. 28)..	.....	1.118	Screw V	1.095	1.140	0.69
Screw V — Screw VI (Fig. 28 and Fig. 25)..	.....	1.20	Screw VI		1.294	Average
Screw VI — Screw VII (Fig. 25 and Fig. 26)..	1.05	0.994	Screw VII		1.18	Average
Screw VII—Lower edge of flange..............	1.08	1.198				

rolling work on the web begins later at a gripping angle of 9 deg. 45 min. for the upper and 9 deg. 48 min. for the lower. In addition it should be mentioned that the forming of the flange begins before the collars of the two rolls touch. Under the pressure of the rolls the inner flange sides are worked by a shearing action so that the stock travels toward the web, while on the outer flange sides, under the action of the friction of the roll collars, the stock is pressed toward the opening of the pass. These procedures are to be studied more closely at different positions in the pass. The position of the screws which were placed for this purpose can be seen from Fig. 23.

Figure 31 shows the perpendicular section of the horizontal screw (I) which was placed 12.8 mm. from the upper flange edge. The screw (II), which was

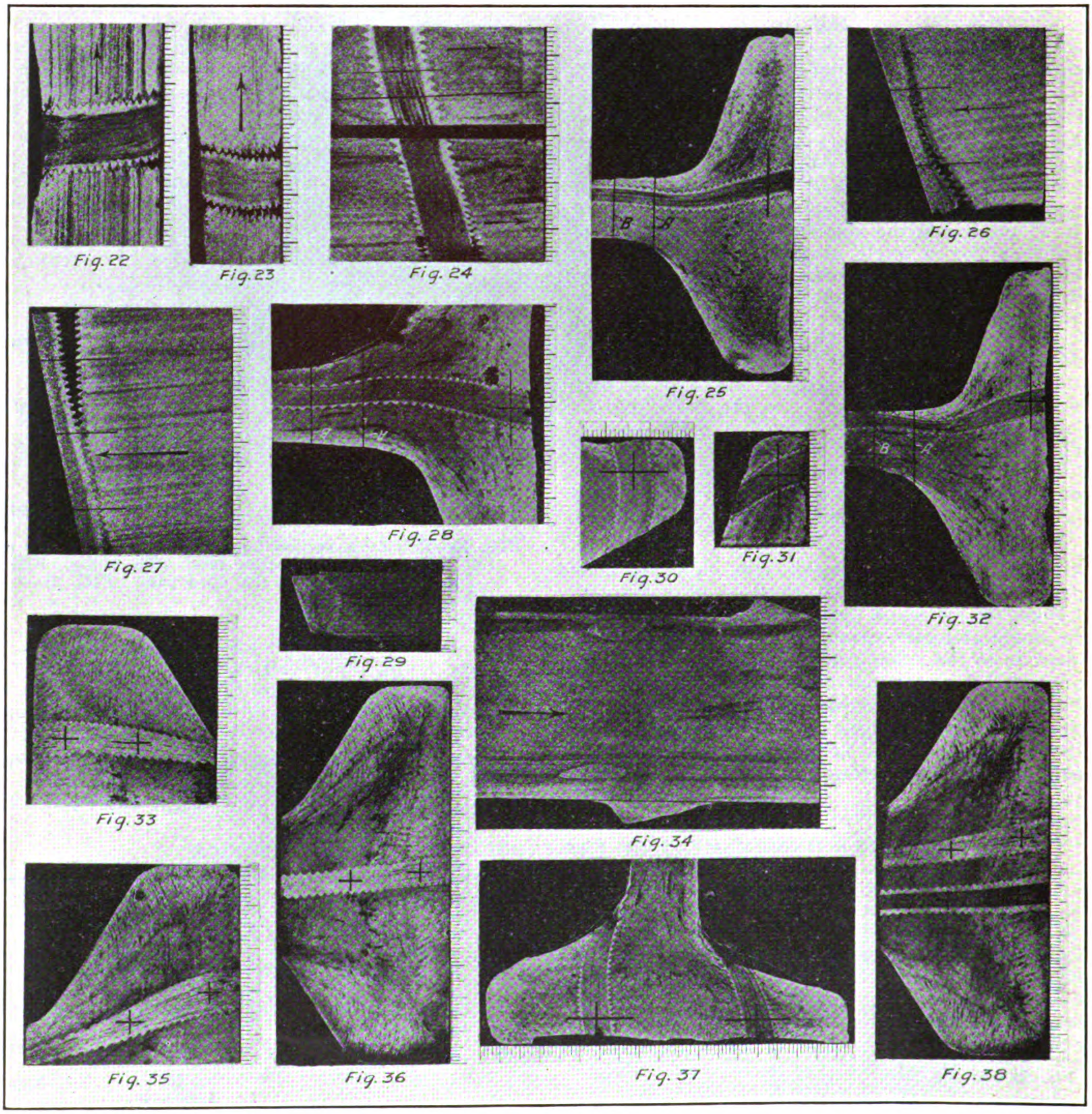

FIG. 22—Same as Fig. 23 (Screw II). FIG. 23—The forward slippage of the side surfaces in relation to the inner surface in the open flange (Screw I). FIG. 24—Section through the horizontal Screw IV in web. FIG. 25—Horizontal Screw IV in web (third pass). FIG. 26—Section of a vertical screw through the whole height of the flange (third pass) open flange. FIG. 27—Section of a vertical screw through the whole height of the flange (third pass). Closed flange. FIG. 28—Horizontal Screw V in web (third pass). FIG. 29—Vertical screw in web (third pass). FIG. 30—Screw VII in lower flange edge (third pass). FIG. 31—Screw I in the open flange (third pass). FIG. 32—Horizontal Screw III in web (third pass). FIG. 33—Screw VI, 36 mm. from the lower edge. FIG. 34—Section through the center of Screws II and VI. FIG. 35—Horizontal Screw II 35 mm. from the upper edge. FIG. 36—Section of horizontal Screw IV through the axis of the starting section. FIG. 37—Screw II in the open flange and Screw VI in the closed third pass. (The material indicated by the white lines had to be removed before the screws could be located.) FIG. 38—Section through the Screws III and V.

placed in the upper flange of Fig. 25 was placed 26.8 mm. from the edge of the flange. In the open flange the perpendicular movement is on the outer sides toward the pass opening, on the inner side it is toward the web; the material movement of the latter is due to the shearing force on the side surfaces.

The lower screw (VI) in Fig. 37 was placed 29.7 mm. from the flange edge while the screw (VII) in Fig. 30 was 13.9 from the lower edge. The material movement of the two flange sides is toward the closed pass.

Web of the Beam

Figures 32, 25 and 28 show sections of the horizontal screws (III, IV and V) placed in the web. Point A donates the position of the cutting point of the inner side of the flange and the upper edge of the web of the roughing pass; point B the same cutting point of the lower flanges.

The illustrations explain the change in shape in rolling; the outer part of the blank moves toward the pass opening, the inner toward the web. The draft in the web fillets is heavier than in the web, and is due to the slipping of the stock on the inner flange sides.

Table II gives the perpendicular movement of the stock; it shows that the highest displacement is to be found at the edge of the upper flanges. This result is in contradiction to the usual opinion up to this time, as the open flange has an upsetting action while in the closed pass this upsetting is smaller. One even notices in the latter case, a slight increase in height. This fact is due to the difference in the working of the two flanges. In the open flange tip both rolls work the flange surface. The movement of the upper roll is from top to bottom (toward the web) that of the lower roll is turned in the opposite direction (toward the pass opening). In the closed flange tip the two surfaces are only worked by the lower roll.

The stock of the closed flanges partly flows in the longitudinal direction; partly into the upper flange. The thickness of the closed flange parts is therefore partly reduced by the drawing action and for this reason these parts are subjected to tension. If the lower edge of the beam touches that of the closed pass, the draft affects this edge and destroys the tension effect to a certain depth in the flange tip. The tension lines in the heaviest parts of the closed tip are destroyed by the rolling draft of the web. The partial increase in height of the closed flange tip can be explained in this matter The movement of the stock on the closed flanges is also checked by practice as it will make the flange too short and cause seam formation in the open pass also a heavy reduction of the thickness causes the same defect. The upset in the open pass is highest on the outer sides. Under the influence, though, of the shearings on the inner side surfaces, the upper part of the side surfaces of the upper flange are subjected to tension.

Distortion of Horizontal Screws

An investigation of the change in shape of the horizontal screws shows that the outer passages suffer a decrease in length, while in the web, the inner flange sides are enlarged.

The heavy friction of the outer side surfaces of the roll on the collars is explained by the sideward displacement of the outer edge section. The decrease in the flange thickness is made possible by an increase in the distance between the two flanges of the roughing pass; it must therefore cause a spreading of the web.

If we consider the section of the horizontal screws set in the flanges, we find that the change in shape is totally different in the latter.* According to our graphic method the open flange is given the same distribution coefficient as the web, but under the condition that the former does not exceed a maximum value of 1.35.† On the contrary for the closed pass the distribution coefficient is only two-thirds that of the web; if the latter value exceeds 1.35, the distribution coefficient of the closed pass is assumed at a maximum value of 1.23.

Figures 26 and 27 show the longitudinal section of a perpendicular screw, which passes through the whole flange height. In this case the end of the open flange is behind the closed flange part about 22 mm. as the material displacement is greatest in the open pass. Also the tensile stress in the closed part is greater than in the open pass, as the release of the screws is in that case very much more pronounced.

Figure 29 shows the longitudinal section of the screw in the web; it shows that the screws were heavily pressed and that the shape of the screw carries the markings of a high rolling pressure.

The horizontal material displacements in the beam are still essential. The side surfaces move ahead of the inner surfaces of the flange as the displacement is in its largest part due to the shearing of the inner flanged sides.

The accelerations with the screw (I) (Fig. 23) amounts to 2 mm.; the release of the screws by the iron is complete. With screw II (Fig. 22) the acceleration is 3 mm.; the release of the screw is only shown at the outer surface.

The acceleration amounts to 4 mm. for screw (VI) (Fig. 17); the release of the screw by the iron is greater than was the case with the two upper screws. Also in Fig. 18 (VII) there is considerable loosening of the screws; the acceleration of the outer end in comparison with the inner amounts to 2 mm.

Figure 24 is of interest as it shows the section through the horizontal screw in the center of the web height. In the flange the axes of the screw has remained straight; it is only inclined toward the web. The acceleration of the outer end amounts to 9.5 mm. measured on a width of 41.5 mm. From this point on, the screw is bent. Opposite the center of the beam the acceleration of the outer end amounts to 11.0 mm. The movement shows plainly that due to the shearing action the stock on the side surfaces of the flange slides off to the fillet of the web and that the rolling draft increases the amount of this material displacement.

Conclusion

By locating screws in different places of the stock it was possible to study the movement of the stock in open and closed passes. The results give an expanation for the higher rolling pressure and power which is necessary for the rolling of beams in comparison with flats with the same elongation.

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*One calls the draft which works on the flanges "indirect." It appears more proper to designate the draft in the open pass as "partial direct" draft, as the rolling pressure in the vertical direction exerts only a partial effect on the sideward material displacement. In the closed pass the effect of the pressure is called "indirect" draft. The direct draft effects the web and also the edges of the flanges.

†Rev. Met. 18 (1919), pages 89-127, and 157-174.

Seamless Steel Tubing; A Bibliography

Practically All Phases of Tube Manufacture Are Covered—Pilger and Mannesmann Processes Receive Special Attention —American and Foreign Practice Reviewed

Compiled by VICTOR S. POLANSKY*

Adam, Alastair Thomas. Wire-Drawing and the Cold Working of Steel. 1925. Witherby.

Brief treatment of the manufacture of seamless tubing by cold drawing, p. 65-67.

Alma Tube Works. 1897. (In Engineering, v. 64, p 130-131.)

Description of solid drawn steel tube manufacture at the Alma Tube Works.

American Railway Association—Mechanical Division. Tubes, Boiler, Lap-Welded and Seamless Steel for Locomotives. 1924. (In Manual of Standard and Recommended Practice, Sec. A, p. 265-270.)

Specifications adopted in 1919 and revised in 1923, covering material for boiler tubes, boiler flues, superheater tubes, safe ends and arch tubes.

American Society of Mechanical Engineers. Standard Rules for the Construction of Stationary Steam Boilers, Known as the A. S. M. E. Code, Formulated by the Boiler Code Committee 1924.

Section 2, p. 102-107, is devoted to specifications for lap-welded and seamless steel and lap-welded iron boiler tubes; p. 108-112, specifications for steel pipes, including seamless steel pipes.

Babcock, Geo. H. On a New Method of Making Tubes from Solid Bars. 1887. (In Transactions of the American Society of Mechanical Engineers, v. 8, p. 564-565.)

Discussion, p. 565-573.

The same, abstract. 1887. (In American Machinist, v. 10, no. 25, p. 4.)

Brief comments on Mannesmann process of seamless tube manufacture.

Balcke, Martin. Schräg-Walzverfahren nebst zugehörigem Walzwerke. 1888. (In Zeitschrift des Vereines Duetscher Ingenieure, v. 32, pt. 1, p. 82-84.)

Theoretical discussion of author's patented process of rolling tubes, and rolling mills used.

Balcke, Martin. Schrägwalzverfahren. 1888. (In Zeitschrift des Vereines Deutscher Ingenieure, v. 32, pt. 1, p. 169-171.)

Deals with the theory of oblique rolling of tubes; being a discussion of a patented process.

Baraclough, W. H. Machinery for Tube Making, etc. 1891. (In Engineer, v. 72, p. 338-339.)

Treats of the Mannesmann process of rolling seamless tubes from solid ingots, p. 339.

Barrée, J. H. H. Notes on the Manufacture of Weldless Steel Tubes by the Mannesmann Process. 1902. (In Iron and Coal Trades Review, v. 65, p. 469-473.)

Paper read before the "South Wales Institute of Engineers," dealing with the kind of steel used, its heat treatment and the method employed in the manufacture of tubes.

Bartlett-Kent Process for Rolling Seamless Pipe. 1901. (In Iron Age, v. 67, April 25, p. 6-9.)

Describes a new process developed, for rolling seamless pipes.

Bayard, R. S. Making Shelby Seamless Steel Tubes. 1909. (In American Machinist, v. 32, pt. 2, p. 599-607.)

The same, abstract translation. 1910. (In Stahl und Eisen, v. 30, pt. 2, p. 1449-1454.)

Lengthy illustrated article describing the manufacture of the tubes at the plant of the National Tube Co.

Beck, Ludwig. Geschichte des Eisens in technischer und kulturgeschichtlicher Beziehung. 5 v. 1891-1903. Vieweg.

Discusses the Mannesmann and the Ehrhardt processes of seamless tube rolling and their development, v. 5, p. 802-808, 884.

Beutner, Victor. Manufacture of Welded Pipe. 1903. (In Proceedings of the Engineers' Society of Western Pennsylvania, v. 19, p. 796-827.)

Discussion, p. 828-834.

The same, without discussion. 1904. (In Iron Age, v. 73, Feb. 4, p. 12-16, Feb. 11, p. 6-13, Feb. 18, p. 10-14.

The same, abstract. 1904. (In Iron and Coal Trades Review, v. 68, p. 110, 178.)

Describes in some detail the manufacture of welded pipes, and briefly refers to the cupping or drawing and the Mannesmann and Stiefel processes of seamless tube manufacture.

Biegsame Metallrohre ohne naht. 1902. (In Journal für Gasbeleuchtung und Wasserversorgung, v. 45, p. 194.)

Abstract of article in "Bayer Ind. u. Gewerbebl.," 1902, treats of the flexibility of seamless tubes.

Billet-Piercing Mill Manipulator. 1926. (In Iron Age, v. 118, p. 1683-1684.)

Describes method of using two mandrels, one being in action while the other is being loaded. The device was designed by Leon Cammen and Robert S. Haydock.

Bock. Herstellung nahtloser Stahlröhren. 1899. (In Zeitschrift des Vereines Deutscher Ingenieure, v. 43, pt. 1, p. 184-186.)

According to the author, seamless tube manufacture dates back to 1853, although only non-ferrous metals were employed. Chiefly an historical review of seamless steel tube manufacture.

Booth, W. H. Inshaw's System of Manufacture of Solid Wrought-Iron Tubing. 1907. (In American Machinist, v. 30, pt. 1, p. 763.)

Describes method of weldless wrought iron tube manufacture and its advantages over steel tubes, for certain purposes.

Borchardt, C. Haltbarkeit des Mannesmannrohren für Wasserleitungszwecke. 1897. (In Journal für Gasbeleuchtung und Wasserversorgung, v. 40, p. 792.)

Brief abstract of article in "Deutsche Bauzeitung," 1897, dealing with the use of seamless tubes for water conduits.

Bousse, Anton. Die Fabrikation nahtloser Stahlrohre, mit einer Einleitung über die Fabrikation geschweisster Eisenrohre. 1908. Jänecke.

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*Carnegie Library of Pittsburgh.

Brings together most of the patent and journal literature on seamless tubes.

Bousse, Anton. Geschichte und Fabrickation gezogener Gasrohre. 1905. (In Stahl und Eisen, v. 25, pt. 2, p. 1114-1121, 1177-1180.)

Deals with the history and presents methods of manufacture of drawn gas piping. Considers seamless tubes.

Camp, J. M., and Francis, C. B. Making, Shaping and Treating of Steel. Ed. 4, 1925. Carnegie Steel Co.

Includes a section on the manufacture of seamless steel tubular products, p. 1084-1116.

Cantelo, W. Boring Long Tubes—A Boring Scheme that Failed and One that Succeeded. 1907. (In American Machinist, v. 30, pt. 1, p. 89.)

Treats briefly of the manufacture of barrels of cannons, or pieces of like shape.

Carman, Albert P., and Carr, Maurice L. Resistance of Tubes to Collapse. 1906. (In University of Illinois Engineering Experiment Station Bulletin 5.)

Describes a series of experiments and tabulates results, on the resistance of metal tubes to collapse when subjected to external hydraulic pressure. Includes seamless steel tubes, and a brief bibliography.

Carpenter, R. C., and Fickinger, P. J. Method of Manufacture and Test of a New Seamless Tube. 1898. (In Transactions of the American Society of Mechanical Engineers, v. 19, p. 754-771.)

Discussion, p. 771-780.

The same, abstract. 1898. (In American Machinist, v. 21, p. 434-435.)

The same, abstract. 1898. (In Engineering, v. 66, p. 260-262.)

The same, abstract. 1898. (In Iron Age, v. 61, June 9, p. 12-13.)

Lengthy treatment of the manufacture and test of tubes made by the Mannesmann process.

Castner, J. Mannesmannröhren-Werke, ihre Entwicklung und ihre Erzeugnisse. 1896. (In Stahl und Eisen, v. 16, pt. 1, p. 102-107, 144-147.)

Description of the Mannesmann Tube Works and the manufacture of seamless cylinders.

Castner, J. Das Röhrenwalzwerk Remschied der Deutsch-Oesterreichischen Mannesmannröhrenwerke. 1895. (In Stahl und Eisen, v. 15, pt. 1, p. 526-531.)

The same, abstract. 1896. (In Journal für Gasbeleuchtung und Wasserversorgung, v. 39, p. 125-127.)

An illustrated description of Mannesmann tubes made at the Remscheid works.

Cebrat, Paul. Seamless Tube Mills Analyzed. 1926. (In Iron Age, v. 117, p. 473-476, 619-620.)

Series of two articles, the title of the second installment, p. 619-620, reads: "Seamless Steel Tube Manufacture."

Discusses the limitations and advantages of five types and nine combinations of processes, the raw materials used, quality of the steel, the handling in the furnace, and claims that the Pilger process is the most successful for the manufacture of seamless tubes.

Chancellor, W. C. Manufacture of Seamless Steel Tubing. 1924. (In Proceedings of the Engineers' Society of Western Pennsylvania, v. 40, p. 217-248.)

The same, abstract. 1924. (In Iron and Coal Trades Review, v. 109, p. 510-512.)

The same, abstract. 1924. (In Railway Review, v. 75, p. 545-551.)

Describes the manufacture as carried out by the Mannesmann process and the operations necessary for the production of hot rolled and cold drawn tubes, with observations on the structure and properties of the material as effected by the cold drawing and annealing of the tubes.

Charnock, G. F. Mechanical Technology; being a Treatise on the Materials and Preparatory Processes of the Mechanical Industries. 1916. Van Nostrand.

Considers the manufacture of tubes in chapter 39, including a treatment of seamless tubes, p. 590-596.

Continuous Straightening Machine for Round Bars and Seamless Tubes. 1923. (In Iron and Coal Trades Review, v. 107, p. 771.)

Two types of straightening machines are briefly described, one for small and one for heavy sections.

Cook, Gilbert. Experiments on the Collapsing Pressure of Tubes. 1914. (In Mechanical Engineer, v. 34, p. 320-322.)

Gives results of tests conducted by author on short solid drawn weldless steel tubes. Includes numerous diagrams, formulas and foot-note references.

Cook, Gilbert. Resistance of Tubes to Collapse. 1913. (In Report of the British Association for the Advancement of Science, v. 83, p. 213-220.)

Bibliography, p. 220-224.

Being a discussion of the existing formulae used for calculating collapse of tubes. Gives formula for the determination of the collapse of solid drawn weldless steel tubes, p. 219.

Cycle Tube Works. 1896. (In Engineering, v. 62, p. 712.)

The same. 1896. (In Engineer, v. 82, p. 573.)

The same, translation. 1897. (In Stahl und Eisen, v. 17, pt. 1, p. 65.)

Brief discussion of the method employed by the Cycle Manufacturers Tube Co. for the manufacture of seamless bicycle tubes.

Daelen, R. M. Progress in Steelworks Practice in Germany Since 1880. 1902. (In Journal of the Iron and Steel Institute, v. 62, p. 46-56.)

Discussion, p. 57-63.

The same, without discussion. 1902. (In Engineering, v. 74, p. 326-328.)

Includes a brief treatment of the processes employed in the manufacture of seamless tubes.

Davies, C. E. Rotary Piercing Machine for Steel and Copper Billets. 1921. (In Engineering, v. 112, p. 397-399, 429-430, 495-496, 527-528.)

Revised translation of Gruber's article in "Stahl und Eisen," Sept. 1919, outlining the theory for rotary piercer, with some remarks on the design and use of the rotary piercer in England. Numerous illustrations and formulas are included.

Davis, T. D., and Graham, J. B. Uniform Methods of Handling and Care and Use of Pipe in Field. 1926. (In Oil and Gas Journal, v. 25, no. 30, p. 120, 158-161.)

Considers briefly the care of seamless interior upset drill pipe, p. 160.

Diegel. Röhrenfabrikation. 1900. (In Verhandlungen des Vereins Beförderung der Gewerbfleisses, v. 79, p. 361-439.)

Discusses the manufacture of iron tubes and gives results of investigations on the influence of various methods of manufacture on the strength of the material. Includes seamless tubes.

Diescher Billet Piercing Process. 1901. (In Iron Trade Review, v. 34, pt. 1, no. 9, p. 12-14.)

Method of great interest inasmuch as a radical departure has been made from methods generally in vogue.

Döderlein, M. Herstellung nachtloser Rohre. 1925. (In Stahl und Eisen, v. 45, pt. 2, p. 1632-1639.)

Review of several processes and abstracting articles by Kelso, Ross and Chancellor.

Dunn, J. Jay. Manufacture of Seamless Steel Boiler Tubes. 1912. (In Boiler Maker, v. 12, p. 140-142.)

The same. 1912. (In Mechanical Engineer, v. 30, p. 333-335.)

The same. 1912. (In Railway and Engineering Review, v. 52, p. 1144-1146.)

Paper read before the "American Boiler Manufacturers' Association," describing the process of manufacture, with brief mention of processes which have at this time been superseded.

Economical Selection of Materials. 1921. (In Machinery, N. Y., v. 27, p. 564.)

Deals with material saving by procuring stock that requires a minimum amount of reworking. Considers seamless tubes.

Ehrhardt, Heinrich. Herstellung nahtloser ´Kesselschüsse ohne Schweissung. 1902. (In Sitzungsberichte des Vereinszur Beförderung des Gewerbfleisses, v. 81, p. 103-107.)

Discussion, p. 107-110.

Describes the method of rolling seamless cylinders.

Ehrhardt, Heinrich. Neues Verfahren zur Herstellung von nahtlosen Holkörpern. 1893. (In Stahl und Eisen, v. 13, pt. 1, p. 473-474.)

Discussion, p. 474-475.

The same, abstract translation. 1893. (In Industries and Iron, v. 15, p. 226-227.)

Describes method of seamless hollow goods manufacture by author's process.

Ehrhardt, Heinrich. Note on the Manufacture of Weldless Steel Pipes and Shells. 1903. (In Journal of the Iron and Steel Institute, v. 64, p. 289-291.)

Discussion, p. 292.

The same, without discussion. 1903. (In American Machinist, v. 26, pt. 2, p. 1436-1437.)

The same, without discussion. 1903. (In Engineering, v. 76, p. 402.)

The same, without discussion. 1903. (In Iron Age, Sept. 17, p. 21.)

The same, without discussion. 1903. (In Iron and Coal Trades Review, v. 67, p. 714-715.)

Author describes his own process, consisting of piercing and drawing out the billets.

Ehrhardt, Heinrich. |Ueber Herstellung grosser Kesselschüsse und schwerer nahtloser Rohre. 1902. (In Stahl und Eisen, v. 22, pt. 1, p. 253-256.)

Discussion, p. 256-258.

The same, without discussion. 1902. (In Kraft, v. 19, p. 320-321, 349-350.)

The same, abstract. 1902. (In Zeitscrift des Vereines Deutscher Ingenieure, v. 46, pt. 1, p. 359-360.)

The same, abstract translation. 1902. (In Iron and Coal Trades Review, v. 65, p. 29.)

The same, abstract translation. 1902. (In Iron Trade Review, v. 35, pt. 1, no. 19, p. 27.)

Paper ready before the "Verein Deutscher Eisenuettenleute," describing the Erhardt process of manufacture of seamless cylinders and tubes.

Ehrhardt Process for Producing Tubes from Blanks by Drifting. 1912. (In Mechanical Engineer, v. 30, p. 187.)

Brief illustrated description of a patented process for the production of seamless tubes.

Ein neues Röhrenwalzverfahren. 1893. (In Glaser's Annalen für Gewerke und Bauwesen, v. 33, p. 129-130.)

Brief article dealing with the methods employed in rolling Mannesmann seamless tubes, and appliances used.

Ein neues Universal—Walzverfahren. 1887. (In Stahl und Eisen, v. 7, pt. 2, p. 451-461.)

Describes Kögel's universal tube rolling mill, and discusses briefly the Mannesmann process which is claimed to be the basic method for rolling seamless tubes.

Ellwood Weldless Tube Company. 1896. (In Iron Age, v. 57, p. 693-694.)

Description of the Stiefel process of making seamless tubes.

Ferry Works Queensberry. 1904. (In Engineer, v. 98, p. 7-10.)

Includes brief discussion of method of solid drawn steel boiler tube manufacture and machinery used.

Finkener. Occurrence of Gas in Iron Tubes Rolled by the Mannesmann Process. 1889. (In Journal of the Society of Chemical Industry, v. 8, p. 398.)

Abstract translation of an article in "Mitheil d. Königl. Techn.," 1889, p. 41. Treats of the cause of gas occurrence, method of collecting and gives its chemical composition.

French, H. J. Manufacture and Properties of Light-Wall Structural Tubing. 1920. (In Transactions of the American Institute of Mining Engineers, v. 62, p. 303-322.)

Discussion, p. 323.

The same, abstract. 1919. (In Iron Trade Review, v. 65, p. 982-985.)

Describes the manufacture and properties of light-walled cold drawn seamless and welded steel tubing for structural purposes. Tabulates results of tests.

Friedmann, J. Begriff der Erfindung und ihre Bedeutung auf rohrtechnischem Gebiet. 1910. (In Röhren-Industrie, v. 4, p. 29-32, 52-53, 72-74.)

A survey of recent patent literature on tubes; includes seamless tube patents.

Fully Hydro-Electric Power Station, Switzerland. 1922. (In Engineering, v. 11, p. 635-639, 665-670, 731-734.)

Includes a brief discussion of weldless steel pipes of large diameter, manufactured by the Erhardt process, being used in the construction, p. 667-668.

Gordon, J. G. Mannesmann Process for Making Seamless Tubes. 1890. (In Journal of the Society of Arts, v. 38, p. 648-655.)

Discussion, p. 655-656.

The same, abstract. 1890. (In Engineer, v. 69, p. 516-517.)

The same, abstract. 1890. (In Engineering and Mining Journal, v. 49, p. 676-677.)

The same, abstract. 1890. (In Engineering News, v. 24, p. 92-93.)

The same, abstract. 1890. (In Industries, v. 8, p. 569-570.)

The same, abstract. 1890. (In Journal of Gas Lighting, v. 55, p. 1028-1029.)

Describes method of manufacture, results of tests and includes a brief historical review of tube making.

Grimshaw, Robert. Punching Out Seamless Tubes. 1903. (In Machinery, N. Y., v. 10, p. 51.)

Description of the method and machine employed for making seamless tubes of circular section by punching them from square bars.

Grosse nahtlose Hohlcylinder. 1901. (In Stahl und Eisen, v. 21, pt. 2, p. 1202.)

Brief discussion of the manufacture of large seamless hollow cylinders.

Gruber, Karl. Ueber die Herstellung nahtloser Rohre unter besonderer Berücksichtigung des Mannesmann-Schrägwalz-Verfahrens. 1919. (In Stahl und Eisen, v. 39, pt. 2, p. 1029-1036, 1067-1075, 1096-1100, 1174-1177, 1204-1208, 1239-1244.)

See also Davies.

The same, abstract translation. 1921. ((In Le Génie Civil, v. 79, p. 225-229, 247-249.)

The same, abstract translation. 1921. (In Iron Age, v. 107, p. 903-905, 977-980, 1011, 1049-1052, 1114-1118.)

The same, partial translation. 1921. (In Blast Furnace and Steel Plant, v. 9, p. 212, 247-252, 320-323, 442-444.)

Series of articles describing the manufacture of seamless tubes by the Mannesmann process, and illustrating the various operations and appliances used.

H., D. A. Uses for Shelby Tubing. 1916. (In Machinery, N. Y., v. 23, p. 320.)

Brief note dealing with the use of seamless steel tube as a spindle in a 16-inch lathe.

H., E. K. Coiling Shelby Seamless Tubing. 1916. (In Machinery, N. Y., v. 23, p. 301.)

Considers briefly method employed by the Roessing-Ernst Co.

Hackett, W. W. Experiments with Weldless Steel Tubing as Used in Construction. 1921-22. (In Proceedings of the Institution of Automobile Engineers, v. 16, pt. 1, p. 387-407.)

Discussion, p. 408-411.

The same, abstract. 1922. (In Practical Engineer, v. 65, p. 21-22, 43-44.)

The same, condensed. 1922. (In Automotive Industries, v. 46, p. 662-665.)

Emphasizes the use of suitable steels, giving methods and results of tests.

Hackett, W. W., and Hackett, A. G. Steel Tubes, Tube Manipulation and Tubular Structures for Aircraft. 1918. (In Aerial Age Weekly, v. 7, p. 724-725.)

The same, abstract. 1918. (In London Times Engineering Supplement, 1918, p. 118.)

Discusses the manufacture and working of seamless tubes, the kind of steels used and the applications of the finished products in aircraft construction.

Halsey, Frederick A. Handbook for Machine Designers, Shop Men and Draftsmen. 1916. McGraw.

Gives dimensions and weights of Shelby cold drawn steel tubes, p. 253, and bursting test pressures, p. 255. Based on R. T. Stewart's investigations.

Harbord, F. W., and Hall, J. W. Metallurgy of Steel. 2 v. Ed. 7, thoroughly rev. 1925. Griffin.

Considers methods and appliances used in the manufacture of seamless tubes, v. 1, p. 456-469, with a brief bibliography, p. 476.

Hauser. Neuere Verfahren zur Herstellung nahtloser Rohre. 1912. (In Zeitschrift des Vereines Deutscher Ingenieure, v. 56, pt. 1, p. 933-934.)

The same, abstract translation. 1912. (In Le Génie Civil, v. 61, p. 306.)

The same, abstract translation. 1913. (In Machinery, N. Y., v. 19, p. 334.)

Method derived from Mannesmann process, but differs from it in that it does not deform the metallic fiber during rolling and drawing of the tube.

Herstellung nahtloser Rohre aus Platten. 1910. (In Röhren-Industrie, v. 4, p. 28.)

Brief description of seamless tubes manufactured by the National Tube Co.

High-Pressure Seamless Steel Cylinders. 1920. (In Iron Age, v. 106, p. 377-379.)

Discusses the manufacture of gas containers from tubes by piercing process and from flat plates by cupping process.

Hock, O. Manufacture of Tubes. 1911. (In Practical Engineer, v. 43, p. 41-42.)

Abstract translation of article in "L'Annuaire de l'Association des Ingenieurs Sortis de l'Ecole de Liege," considering briefly the manufacture and application of weldless tubes.

Hoffman, H. O. General Metallurgy. 1913. McGraw.

Treats of metal rolling with brief reference to the Mannesmann process, p. 647-648, and contains numerous foot-note references.

Holverschied, A. Die Walzwerke; Einrichtung und Betrieb. Ed. 2, rev. 1923. Gruyter.

Treats of rolling seamless tubes by the Mannesmann process, p. 129-136.

How Shelby Seamless Tubes are Made from Plates. 1909. (In Industrial World, v. 43, pt. 1, p. 222-225.)

Describes the cupping process used in making Shelby seamless tubes of large dimensions.

Hughes, Charles H. Handbook of Standard Details for Engineers, Draftsmen and Students. 1921. Appleton.

Contains tables giving comparison of wrought iron pipe and Shelby seamless steel tubing, and tensile and physical properties of Shelby cold drawn tubes, p. 168-169.

Hütter, J. Gusseisenröhren und Mannesmannröhren. 1903. (In Zeitschrift des Österreichischen Ingenieur- und Architekten-Vereines, v. 55, pt. 2, p. 680-682.)

Discussion, p. 682-686, 696-698.

The same, abstract. 1903. (In Eisen-Zeitung, v. 24, p. 227, 273-274.)

The same, abstract. 1904. (In Journal für Gasbeleuchtung, v. 47, p. 399.)

The same, abstract. 1904. (In Stahl und Eisen, v. 24, pt. 1, p. 189-191.)

Compares the durability of cast iron and Mannesmann tubes.

Improved Die for Drawing Seamless Tubes. 1908. (In Brass World and Platers' Guide, v. 4, p. 124.)

Brief discussion of a patented appliance for the improvement in drawing metal tubes.

(To be continued)

Open Hearth Furnace Construction

It Is Desirable to Know the Fusing Point of the Various Refractories Entering into Furnace Construction—Kind and Quality of Brick Stressed—Chrome Ore Used

By C. W. VEACH

A KNOWLEDGE of the physical chemistry involved in the temperature of formation of silicates, as well as other metallurgical salts, is useful to the engineer who constructs open-hearth furnaces or manufactures refractories, and is indispensible to those charged with operating furnaces. It is well known that pure silica melts at a high temperature, and magnesia at a still higher temperature. Likewise lime, in the oxide state, (CaO) is infusible at any temperature obtainable in the open-hearth furnace. Silica and lime, or silica and magnesia, brought together at moderately high temperatures, reacts to form a slag, whose fusion temperature is lower than that of either one of these elements when in the pure state.

The exact fusion temperature of slags will depend on the amount of basic material present when the acid process is employed, or on the amount of acid material present when the basic process is used. It must be noted that the amount of either acid or basic material permissible, in either the basic or acid process, is less than an amount sufficient to soften the bottom, i.e., lower the fusion point of the bottom material. These facts do not concern the engineer directly, but they do concern all of those who are concerned with the operation of the furnace.

What interests the engineer most is the choice of a brick that will give the best service in that portion of the furnace in which it is placed. In the hearth, bricks should be used which will be neutral to the slag, whether it is acid or basic. In the acid furnace silica bricks will be used, while in the basic furnace bricks of a like composition will have to be used. No brick is impervious to liquid slags, but some are more so than others. There are stages in the basic process when the slag is acid, and at such times if the slag splashes against the brickwork it will be rapidly cut. Even the neutral chromite brick will suffer erosion by the splashing slag. To guard against the erosion of the bricks at the slag line, the banks should be built high with magnesite, dolomite, or a specially prepared chrome ore of which more will be said in a later article.

Use of Chrome Ore

The covering of chrome ore serves a dual purpose in that it protects the brickwork from the erosive action of the slag, and the magnesia bottom from the silica dropping from the backwall and skew backs. By covering the slopes, at the ends of the furnace, With crome ore, the brickwork is protected from the action of any solid matter carried in the waste gases, and from the silica dripping from the roof. There is much discussion concerning the best lines to which a furnace should be constructed as the kind of fuel burned has a considerable bearing on the design of the port end, and affects the furnace as a whole.

Many engineers recommend a deep bath, with the furnace sides straight, and sufficient distance from the point of combustion to the bath to allow the flame to attain its maximum temperature near the center of the bath. If combustion does not take place near that end of the furnace at which the fuel enters, some of the fuel may pass the bath before burning completely and waste result. Even if the bath is long enough to allow the fuel to burn completely before passing to the ports, a short slope will not allow the flame temperature to develop quick enough to heat the metal at the end, at which it enters.

The ideal temperature conditions in a "sharp" working furnace, burning fuel oil, is as follows: At the first door on that end of the furnace, where the gas enters, the temperature will be about 3200 deg. F., at the center door it will approximate 3100 deg. F., and at the door near the out-going end the temperature will be about 3000 deg. F. The above temperatures may be increased somewhat if it is desired to drive the furnace hard, but hard driving increases cost of upkeep and, if carried too far, results in a decrease in the quality of the product and increased metal loss.

For sometime operators have recognized the need for prolonging the life of the backwall, frontwall, and port ends of open-hearth furnaces, since failure in any one of these vital parts, unless taken care of at once, will result in loss of time and entails expense which is not always taken into account when estimating the cost of the furnace upkeep.

Expense from Lost Time

Besides the cost of repairs there is the expense of lost time, loss of earnings by the furnace operators, and loss of stored heat which is tremendous in a furnace of large capacity. Furthermore, the rapid cooling and heating of the bottom harms it when week-end repairs are made.

Also there is the cost, which we do not always consider in cooling the furnace below red heat. This cooling causes the old brickwork to shrink and settle back to its original position, and as it is glazed, to a depth of ½ to ¾ of an inch, it does not settle uniformly. When again heated the true lines of the walls are lost, and the roof weakened by uneven expansion so that the arch is no longer true. Then, too, heating up after a minor repair is usually done with less care than is exercised on the initial heating, hence, spalling sometimes occurs. If operators are ever successful in reducing week-end repairs to one, per furnace campaign, much of the upkeep cost will be eliminated, and the masons will not be required to expose themselves so often to the intense heat which they face when making repairs.

Allowing 350 heats for a campaign, if we can run continuously until half of this number of heats has been made, and then renew all the weak parts, and again run continuously until the campaign is ended, it would be less costly then to shut down for several minor repairs. How this condition is to be improved, how to secure materials of higher quality for the vital parts, and how the operators of the furnaces should be instructed in caring for the furnaces, and obtaining better control of the flame, as well as the influence of the chemical reactions are problems for open-hearth superintendents to solve. As these questions are of vital interest to all, because they affect the cost, and involve the conservation of materials, they should be openly and freely discussed among those interested.

Here the producers of ceramic products have a field in which they could work to the mutual advantage of all. The writer has devoted considerable time endeavoring to find a satisfactory solution of some of these questions, and has come to the conclusion that all of the failures of materials can not properly be charged to their inferior quality.

We have been lax in giving our operators those instructions which the case demands, hence they are not always capable of coping with the conditions which may arise. At times a furnace will be badly damaged and its life shortened by wrong handling, before the operator realizes what has happened. At such times it is generally found that damage to the furnace is caused more often by ignorance than by neglect.

Improvements

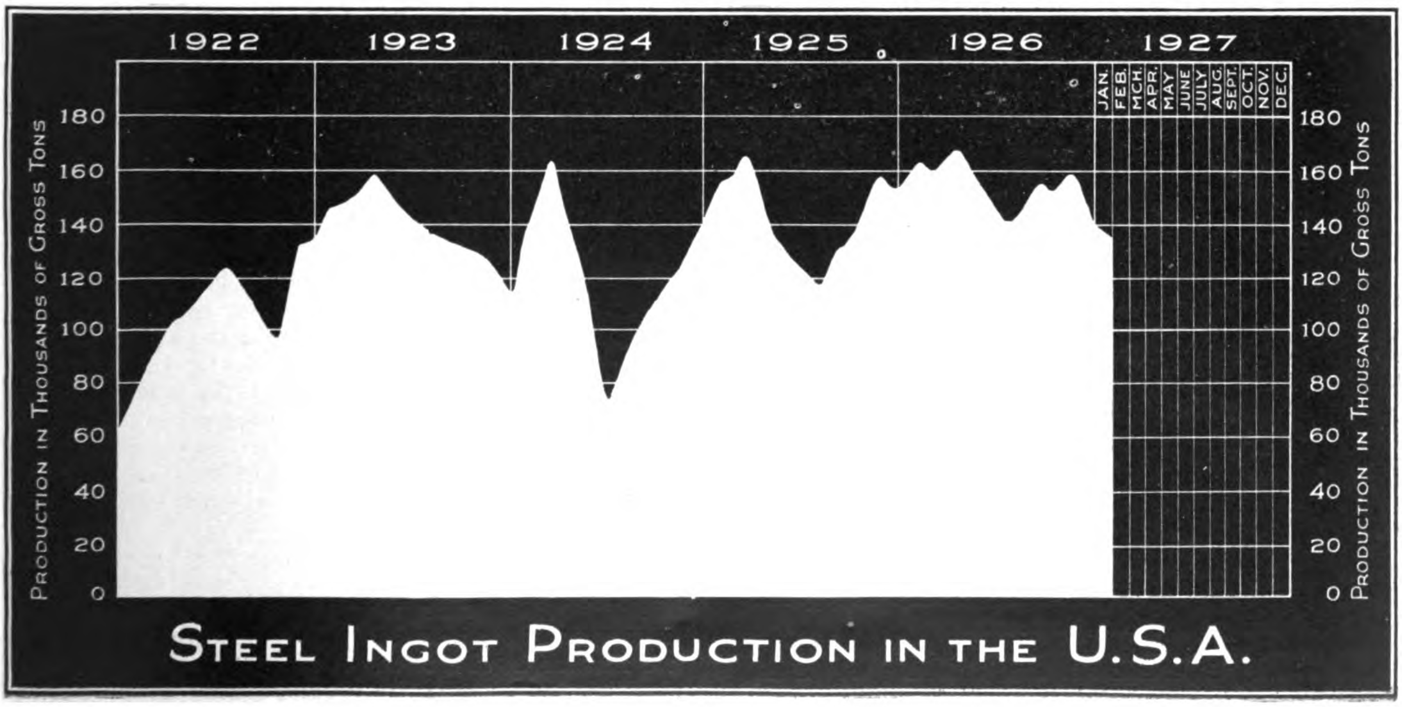
Within the last few years some new departures have been undertaken, which merit impartial consideration. The suspended arch roof appears to offer advantages, where a span of more than 12 feet is required, because on a wide furnace the roof can not be worn thin, as it will drop from its own weight especially if it happens to burn thin on one side while remaining heavy on the other. The construction of furnace walls with chorme ore has been tried and a recent survey discloses that considerable economy resulted from its use, although the initial cost was considerably higher than when the standard materials were used. In this survey it was shown that the chrome ore backwall cost almost three times as much as a similar wall built of silica bricks resting upon the usual magnesite base. A saving was effected in reduced week-end repairs.

The materials used in refractory bricks must conform to the following requirements:

1—They must not soften at, or below, the temperature to which they will be subjected when in place; 2—They must not crumble; 3—They must not expand excessively; 4—They should take no permanent set when expanded; 5—They should not conduct heat; 6—They should be impermeable to gases; 7—They should resist mechanical abrasion; 8—They should be impervious, chemically, to substances in contact with them. Some bricks have many of these qualities, but not all, and it is doubtful if we will ever have a refractory brick that will embody all of them.

Activities in the Steel Market

STEEL plant production in January averaged close to 70 per cent. In the Chicago district ingot output was slightly over 80 per cent of plant capacity while in the Pittsburgh district it was about ten points lower. Tonnage hauled by the railroads has been maintained at a high level. Orders from automobile manufacturers are being placed in greater volume with prospects brighter for an increase in February. While there has been a somewhat general increase in demand for steel products, the improvement has been most pronounced in the Chicago district. Sheet and Plate Mills show greater activity, but there has been no favorable response in demand for bars and structural shapes. Prices generally are being maintained with exception of some slight concessions in the sale of pig iron and steel bars.



STEEL INGOT PRODUCTION IN THE U.S.A.

The POWER PLANT

The Embrittlement of Boiler Plate

Reasons for Formation of Cracks Are Clearly Outlined—Micrographic Studies Aid in Determining Character of Cracks —Causes and Prevention of Embrittlement

By FREDERICK G. STRAUB*

WITHIN recent years, a phenomenon of more or less frequent occurrence has become recognized, to which the term "the embrittlement of boiler plate" has been applied. Because of the relatively infrequent occurrence of this difficulty and the more or less obscure causes which bring it about, the fact of embrittlement has been largely in question, and both the evidence of its presence and the conditions which promote it are matters of importance at the present time. This is all the more accentuated by reason of the fact that seemingly within recent years an increased number of boiler failures chargeable to embrittlement are in evidence.

By embrittlement is meant the embrittling and subsequent cracking of the boiler plate. This is usually characterized by cracks between the rivets. Figs. 1 and 2 show the characteristic cracks in sections from embrittled boilers.

Cracks in riveted joints are generally attributable to steel of unsuitable quality, to excessive stresses in the plates caused by too high riveting pressure, imperfect thermal and mechanical treatment during fabrication, and extremely severe operating conditions. Cracks from such causes occur in the riveted joints both above and below the water line of the boilers.

Since boiler plate is made from mild steel low in impurities, its ductility is high and most fractures due to overstressing the metal should be accomplished by a marked elongation of the plate previous to failure. Fig. 3 shows a micrograph from a boiler plate which failed due to overstressing. The crack progresses across the grains which are elongated in the direction of stress.

Formation of Cracks

When steel is placed under reverse stress (fatigue), as failure is approached, cracks develop which upon micrographic study reveal a positive characteristic which serves as a ready method of identification. By examination of a few type specimens it is obvious that the cracks which have been started as a result of fatigue do not respect the fact of grain structure in the metal, but follow a course quite independent of grain boundaries and are hence described as transcrystalline in character as opposed to intercrystalline in their directional development. Fig. 4 shows a micrograph of Armco iron cracked by fatigue in which the typical transcrystalline cracks and grains free from elongations can be seen.

If steel is subjected to corrosive conditions, it may fail much below its normal strength due to the weakening of the metal by the corrosive action. This follows in principle the well-known phenomenon where parts of a metal differ in composition or physical properties from other parts, due to strains, or density, or impurities. In the presence of an electrolyte, by reason of the fact that one portion of the metal is electropositive to another, a galvanic circuit is set up, there is started a solution action on the positive side, and a corrosion area is thereby developed. These corrosion areas or cracks in the case of metal under stress will follow the lines of stress as would naturally be expected. Also, since the solvent action is accentuated, or occurs in the presence of that type or ionization wherein the hydrogen ions predominate, one would expect to find such examples of corrosion in the presence of electrolytes, as nitrates, chlorides, or sulphates. Such corrosion phenomenon would be checked or inhibited by the presence of hydroxyl ions or that condition where an alkaline state exists. This in itself will explain why one would not expect to find corrosion cracks in boilers using waters which are alkaline in character. A study of chemical corrosion does not necessarily require a micrographic anal-

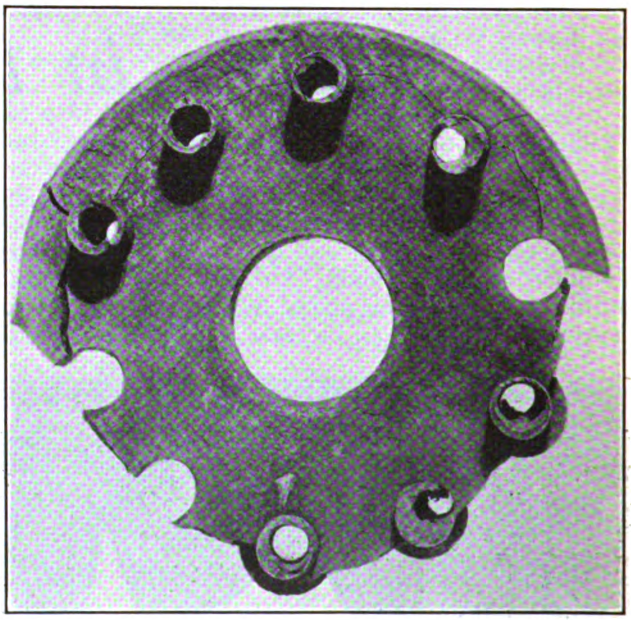


FIG. 1—Characteristic cracks in blow off flange.

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ysis of the structure of the corroded surface. The accompanying illustrations (Fig. 5) shows both the unmagnified and the magnified surfaces of cracks of this character. The specific feature should be noted in the micrograph, namely, that the direction of the cracks follows the lines of stress without regard to grain areas, that is, the crack proceeds across the grains and disregards the grain boundaries in their path of development.

Micrographs Identify Cracks

It is now possible to differentiate those cracks which accompany embrittlement from any of the types already described for the reason that a micrographic study shows one distinctive characteristic of this type of crack. By reference to the micrographs of embrittlement cracks, especially when the surface is etched in such a manner as to bring out clearly the grain boundaries, it is very evident that, almost without exception, these embrittlement cracks follow grain boundaries. A few typical micrographs illustrating the point are shown in Fig. 6.

With this very definite method of identifying any cracks which may occur in connection with boiler plate, it has been possible to make an extended survey of the situation geographically, as well as from the standpoint of boiler fabrication and of boiler water treatment.

It would be impossible within a reasonable space to give in detail the evidence of embrittlement which has been assembled in connection with this type of failure. Reference is made to a few typical samples only. In general the cases of embrittlement may be discussed under four headings: (a) Regional areas where a specific type of natural water exists; (b) waters causing embrittlement as the result of the direct application of chemicals; (c) type of boiler; and (d) quality of boiler plate.

(a)—It is clearly evident that certain regional areas may be defined in which embrittlement is more evident than in others. The waters of those regions are characterized by an almost complete absence of sulphates, but this is accomplished by another vary marked characteristic, and the one which is primarily responsible for the embrittling action, namely, the presence of free sodium bicarbonate. It will thus be seen that these waters have only temporary hardness due to the presence of bicarbonates of lime, magnesium, and iron, and that there is a substantial absence of sulphates of these elements. Areas of this type may be located in a general way as shown on the map in Fig. 7.

(b)—The cases of embrittlement which can be traced to water treatment are comparatively few in number, but the possibilities of such distress, if even remotely present, should be thoroughly understood and the knowledge of how to avoid the difficulty should be quite as eagerly sought by water treating establishments as by the users of such water treating formulas or apparatus.

(c)—The type of boiler seems to be without effect so far as tendency toward embrittlement is concerned, and any idea that one type of boiler is more subject to this trouble than another appears to be wholly without foundation. That is to say, instances of embrittlement have been found in boilers of different makes and designs in sufficient number to warrant the statement that the embrittling effect is not confined to any particular make or type of boiler, all of the standard makes of both fire and water-tube boilers being represented in the investigation.

(d)—Not a little controversy has also centered in the question as to whether the embrittling effect may not be due to faulty composition of the iron. This question seems to have been decided to the effect that embrittling action occurs without regard to the impurities or composition of the plate and that any idea that embrittling distress may be due to faulty iron is without basis in fact. By this is meant that embrittlement is not confined to faulty or dirty iron, but occurs quite as consistently in iron of the best grade as in lower grade iron.

Characteristcs of Embrittlement Cracks

The salient features which are characteristic of embrittlement may be more fully understood after an examination of a few typical examples taken from numerous cases which have been investigated. Fig. 1 shows an embrittled blow off flange and Fig. 2 an embrittled head.

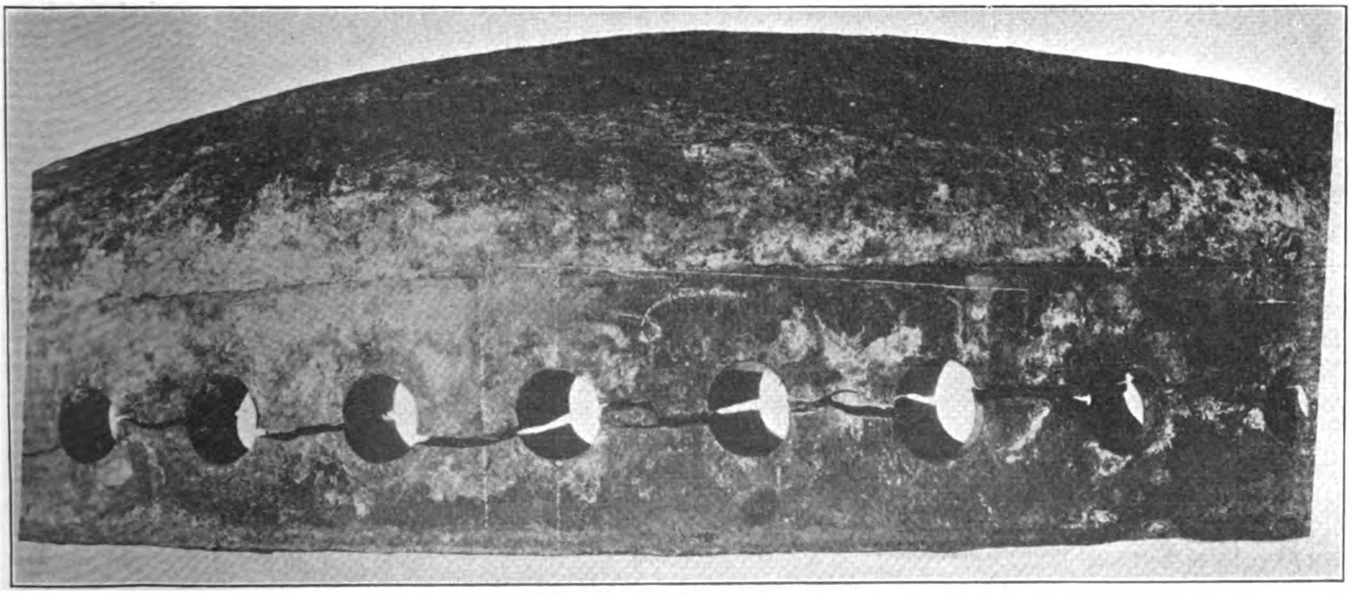

FIG. 2—Embrittled mud drum head.

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TABLE I—CHEMICAL ANALYSIS OF METALS TESTED

Reference	Description	Content Per Cent						
		Carbon	Mn.	P.	S.	S.	Ni.	Mo.
F. S.	Flange steel	0.18	0.45	.012	.027	...	....	...
Armco	Armco iron	0.023	.017	.003	.010	.01	....	...
M. I.	Magnetic iron	0.04	.020	.004	.007	.01	....	...
C. R.	Cold rolled	0.30	0.42	.015	.044	.04	....	...
1112	S. A. E. 1112	0.15	0.76	.215	.126	.01	....	...
2312	S. A. E. 2312*†	0.115	0.45	.018	.025	.20	3.5	...
2212	Special*†	0.13	0.45	.018	.020	.26	1.57	.25
2330	S. A. E. 2330†	0.30	0.478	.023	.015	.05	3.42	...

*Furnished by Central Steel Company, Massillon, Ohio.
†Cut to ¼-inch flat from 1¼-inch round.

The characteristics of these cracks may be summarized as follows:

(a)—The cracks do not follow what is generally considered the line of maximum stress,

(b)—They start on what is termed the dry side of the plate.

(c)—They run, in general, from one rivet hole to another, though they often run past each other, leaving islands of plate.

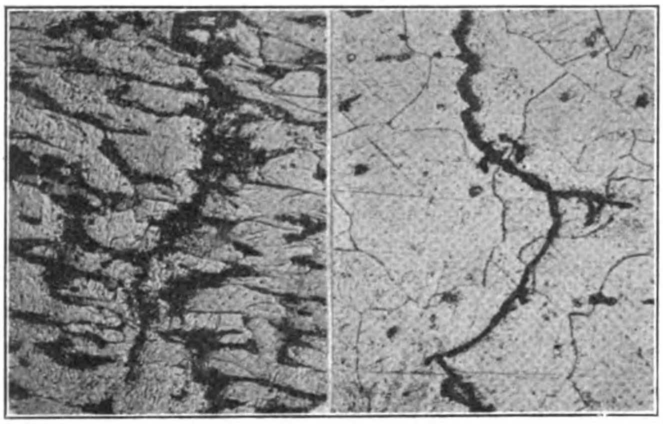

FIG. 3 (Left)—Micrograph of overstressed boiler plate. x 250.
FIG. 4 (Right)—Fatigue crack in Armco iron. x 350.

(d)—They are irregular in direction.

(e)—They never extend into the body of the plate beyond the lap of the seam.

(f)—There is no elongation of the plate.

(g)—Where extreme action has occurred rivet heads crack off or are easily dislodged by a slight blow of the hammer.

A summary of conditions relating to the location of cracks in the boiler may be given as follows:

(a)—The cracks always occur below the practical water level.

(b)—They occur in seams under tension.

(c)—They are found at places where the highest localized stresses might be assumed to occur.

(d)—The cracks occur in plates having practically perfect chemical composition and physical properties, as well as in plates of inferior make.

A summary of the chemical conditions which characterize the water used in the boilers where embrittlement has occurred is as follows:

(a)—Sodium carbonate is the one substance which is always present in the feed water.

(b)—Sulphate hardness is usually absent or of a low ratio with respect to the sodium carbonate present. Sodium sulphate is similarly lower in amount than the sodium carbonate.

(c)—Boilers encountering this trouble use waters having the characteristics noted under (a) and (b), and as a consequence of chemical reaction within the boiler, develop a caustic condition with the sodium hydroxide in material excess over the sodium sulphate.

Reproduction of Embrittlement

It will be evident at once that if a method could be devised for reproducing the feature of embrittlement at will, a ready means would be available for determining both the cause of and the remedy for the difficulty.

Intercrystalline cracking of mild steel is an abnormal type of failure; consequently, if mild steel can be made to crack in this manner under conditions which may be controlled or modified at will, and under conditions which parallel those of actual boiler operations, both the cause and the remedy may be in a fair way of discovery.

The apparatus used for the reproduction of embrittlement is shown in Fig. 8. It consists of a welded

TABLE II—TENSION TESTS OF MATERIALS USED

Reference	Description	Heat Treatment	Proportional Elastic Limit	Yield Point	Ultimate Tensile Strength	Reduction of Area Per Cent
			Lbs. per Square Inch			
F. S.	Flange steel	As received	32,600	35,200	60,400	61
Armco	Armco iron	Annealed 950 deg. C.	32,000	40,600	52,600	70
M. I.	Magnetic iron	Annealed 950 deg. C.	25,000	30,000	50,700	72
C. R.	Cold rolled	As received	70,000	84,000	85,500	55
C. R. A.	Cold rolled	Annealed 850 deg. C.	.....	36,400	64,700	55
1112	S. A. E. 1112	Annealed 900 deg. C.	47,500	49,000	74,000	56
2312	S. A. E. 2312	Annealed 900 deg. C.	37,000	40,000	74,800	75
2212	Special	Annealed 900 deg. C.	35,000	36,800	75,000	75
2330	S. A. E. 2330	Annealed 850 deg. C.	41,000	49,200	77,300	57

Annealed specimens heated to temperature indicated for 30 minutes and furnace cooled.

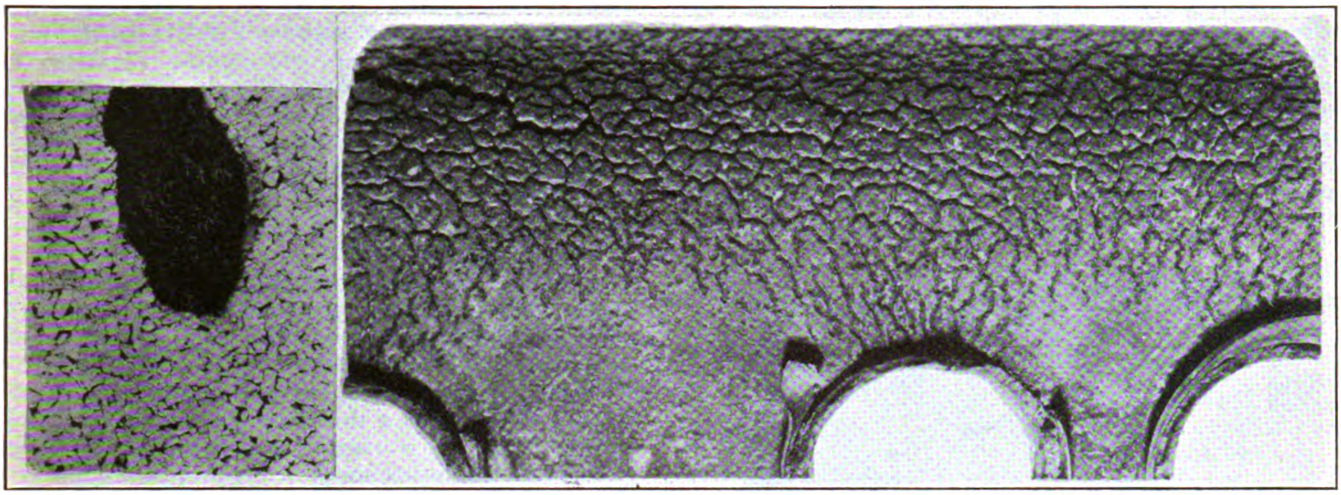

FIG. 5—Corrosion cracking of locomotive flue sheet.

steel container A, which holds the solution, and B, the tension producing equipment. The tension is produced and maintained by means of the spring C and the plunger D. The gland E allows the plunger to enter the container steam tight. The specimen is shown at F. Part B fits into A and is secured by bolts (not shown). The proper temperature and pressure is maintained by means of an electric furnace.

The materials used for the embrittling tests were all mild steels. Table I gives the chemical analyses and reference numbers of the different metals tested; Table 2 gives the physical properties.

The results of the tests on embrittlement* indicate that two conditions must be present simultaneously to cause embrittlement of mild steel: First, the actual stress must be above the region of the yield point of the metal; and second, the concentration of sodium hydroxide must be in excess of 350 grams per liter (350,000 parts per million, about 20,000 grains per gallon).

The variation of pressure up to 200 lbs. per sq. in. seems to have no marked effect on the rate of embrittlement.

Distilled water, sodium carbonate solution, or sodium sulphate solution used in place of sodium hydroxide did not affect the metal even when the stress was up to the point of failure when sodium hydroxide was used.

The temperature of the previous complete annealing had no marked effect on the rate of embrittlement, neither had the stress, once the yield point was passed.

If the metal has been cold worked to an excessive degree previous to testing for the rate of embrittlement the stress necessary to start this effect will not be lowered, but from the evidence at hand it appears that a higher stress will be required than for the original unworked metal.

Chemical Composition of Plate

Pure iron was embrittled in the same manner as boiler plate. Variation of chemical composition of the metal within the limits set for flange steel has very little effect on the rate of embrittlement. Thus, steels of the following general composition show no noticable variation in behavior with respect to embrittling action:

Mn	0.017 to 0.45	per cent
S	0.007 to 0.027	per cent
P	0.003 to 0.012	per cent
C	0.023 to 0.30	per cent

The introduction of 3.5 per cent nickel with the carbon either 0.115 or 0.3 per cent has no effect other than raising the yield point and, consequently, the initial stress necessary to start embrittlement.

When the sulphur becomes 0.215 per cent and the phosphorus 0.126 per cent the rate has a marked acceleration.

The embrittled specimens are not corroded, but are covered with a thin shiny blue-black coherent coat of magnetic oxide of iron. They show no marked elongation or reduction of area at the break. Fig. 9 shows the fracture of an embrittled specimen as compared with that of a regular unembrittled specimen.

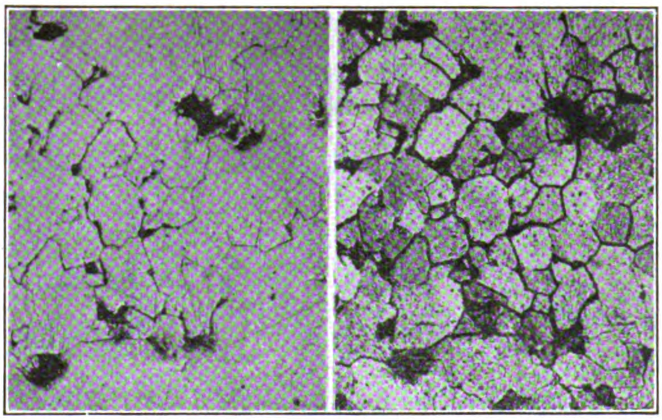

FIG. 6—Micrographs of embrittled boiler plates. (Left)—Unetched. x 250. (Right)—Etched. x 250.

Samples of cracked steel obtained from different instances of this type of boiler distress and examined under the microscope, show the cracks to be intercrystalline. The manner in which mild steel fails under ordinary stress, either static or fatigue, is almost invariably transcrystalline. The fact that embrittlement cracks progress between the grains indicates that this is not a normal fracture. Furthermore, the crack progresses without any marked deformation of the grain, another deviation from the general behavior of mild steel static failures.

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*The complete results of these tests are embodied in bulletin No. 155, Eng. Exp. Sta., University of Illinois. "The Cause and Prevention of Embrittlement of Boiler Plate," by S. W. Parr and Frederick G. Straub.

The specimens embrittled in the laboratory have been examined and found to have a large number of cracks progressing into the strained portion of the metal and all of these are intercrystalline without any marked deformation of the grain, as is shown by the micrographs in Fig. 10.

Prevention of Embrittlement

Since embrittlement is the result of the combined action of chemicals and stress on the metal it appears possible to stop it by at least one or two methods. One of these would be reducing the stress to a point where embrittlement will not occur. This might be possible if the actual concentrated stresses, such as at rivet heads, around rivet holes, etc., could be calculated, and the boiler constructed so as to keep these stresses low enough. Even this would not insure an absolute prevention, since some unknown localized stresses might still exist and give rise to the embrittled condition.

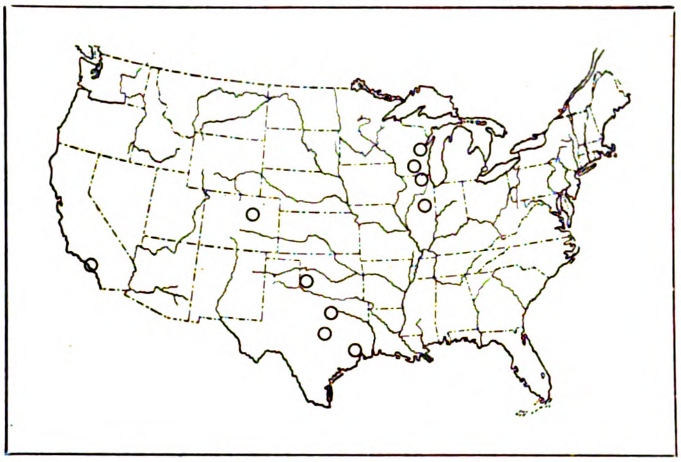

FIG. 7—Waters from areas shown in the above map show a greater embrittling tendency than others.

The other method, namely, the removal of the cause of the chemical action, in the absence of which embrittlement would not occur, would be the best procedure; but even this is prevented in some cases by the fact that a change of water is not always possible. A close approach could be made to this condition by neutralizing the alkalinity with some chemical, but complete neutralization would be impossible without endangering the boiler.

When it is noticed that embrittlement never has occurred even in carbonate waters when the sulphate content is high, the question is raised as to whether or not the existence of a definite ratio between the sodium sulphate and the sodium hydroxide is sufficient in itself to prevent this cracking.

Tests run in the laboratory show that when the sulphate content is increased the time for embrittlement to take place increases, and when the sulphate becomes twice the sodium hydroxide the cracking is stopped entirely.

Effect of Sulphate-Carbonate

The effect of a sulphate-carbonate ratio in plant operation has been studied in one plant for a period of 10 years. This plant, the University of Illinois power plant, had been experiencing embrittlement troubles for some time, and, when three new drums had to be replaced in 1915 after only five years of service, the following system of water treatment was inaugurated:

The sulphate-carbonate ratio of the feed water is maintained at 2. This is done by neutralizing about 70 per cent of the sodium carbonate alkalinity with sulphuric acid. The water is treated in two 40,000-gal. settling tanks. About 110 lbs. of lime is added to each tank and, after sufficient agitation and settling, the required amount of acid.

Analyses are made of each tank after lime treatment and again after the acid is added to determine total alkalinity. Daily analyses are also made of the water in each boiler for causticity and total alkalinity.

After 10 years of operation on this treatment the boilers were given a thorough inspection during February, 1926. Test rivets were removed and a close inspection made for signs of leaking or cracks around the rivet holes. At that time the boiler inspector from the Hartford Steam Boiler Inspection & Insurance Company pronounced the drums to be in perfect condition. The rivets were redriven and the boilers are back in operation.

A system of tratement on a continuous flow principle has been devised and is now in use in certain central power plants in the Chicago district. The water is a zeolite treated water low in the sulphate-carbonate ratio. This ratio is raised by allowing a definite amount of dilute acid to flow into a mixing chamber through which a definite amount of water is being passed. A regular chemical analysis of the boiler water is also maintained at these plants.

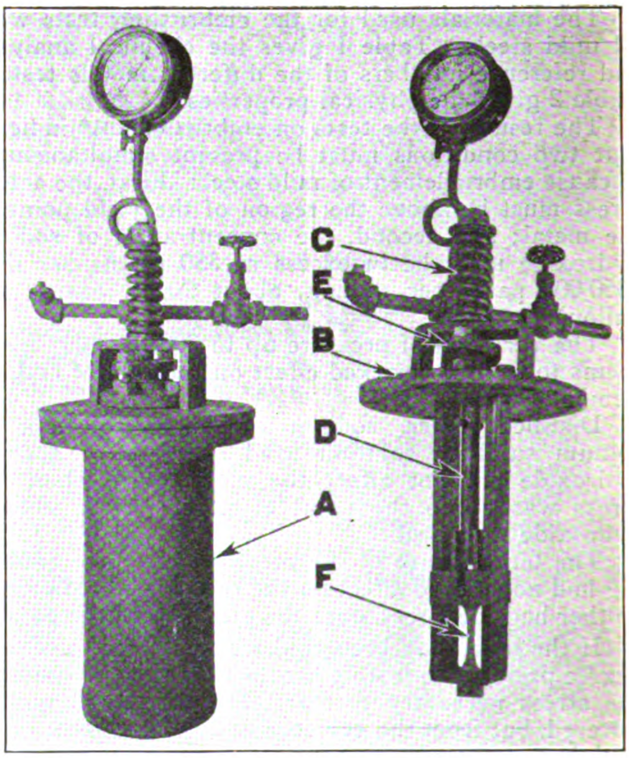

FIG. 8—Apparatus used to reproduce embrittlement.

A power plant in Champaign had boilers go into service in 1916 using the same water as the University of Illionis, but without the sulphate treatment, and in 1925 considerable trouble was experienced due to embrittlement. These two plants operating for nine and ten years, within 20 pounds of the same steam pressure, and upon precisely the same type of water, one acid treated and the other not, serve as a long time experiment with results that are strictly in accord with the laboratory indications. The boilers using the treated water are in excellent condition, while the others have been condemned after only nine years of service.

Causes of Embrittlement

It has already been shown that the production of intercrystalline cracks in mild steel can be brought about only by the combined action of stress and proper chemical attack. The limits set for each of these factors apply only to the conditions of the laboratory tests and the time occupied in these tests. There is a possibility of a slower action taking place over a period longer than that covered by the tests, which may lower to some degree the stress, or the concentration of solution necessary. Another point to be considered is that the embrittlement tests were run with the metal surrounded by a solution; in boilers the solution is penetrating between the plates in a thin film and the limits of concentration of solution necessary to produce embrittlement may be altogether different.

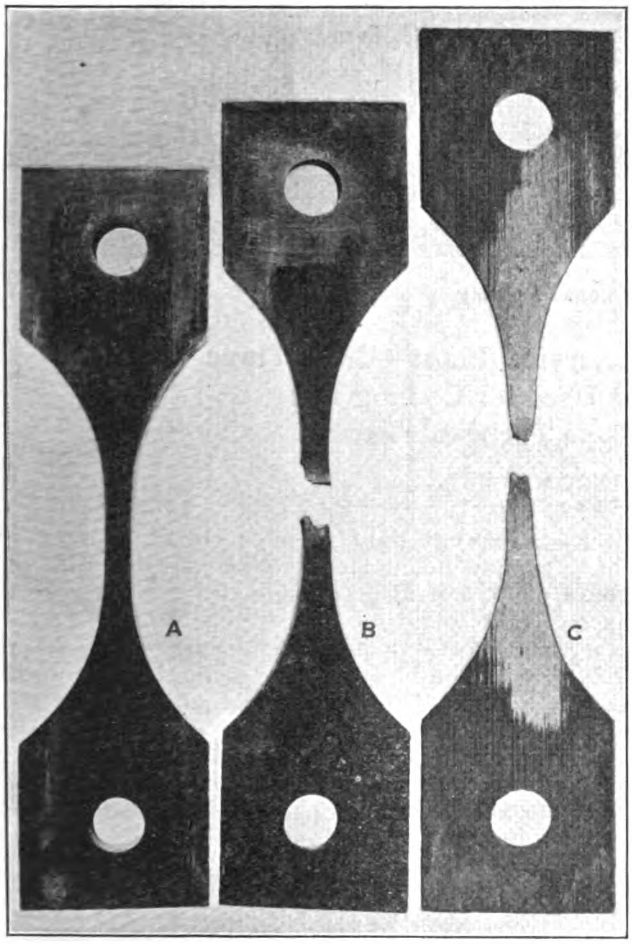

FIG. 9—Embrittled tensile test specimens.

When one considers that embrittlement has been observed in the riveted areas which are under tension, it is possible to conceive that in such locations the stress may pass the yield point and the solution reach the high concentrations used in the tests.

Probably in all boiler plates the stresses at the edge of rivet holes occasionally reach the yield point of the metal. It should be remembered that the mathematical theory of elasticity indicates that the localized stresses at the edge of a hole in a plate may be nearly three times the average stress in the plate. This stress concentration at the edge of holes, such as rivet holes, would itself be sufficient to account for stresses almost high enough to start embrittlement should a solution of proper concentration penetrate to the rivet holes.

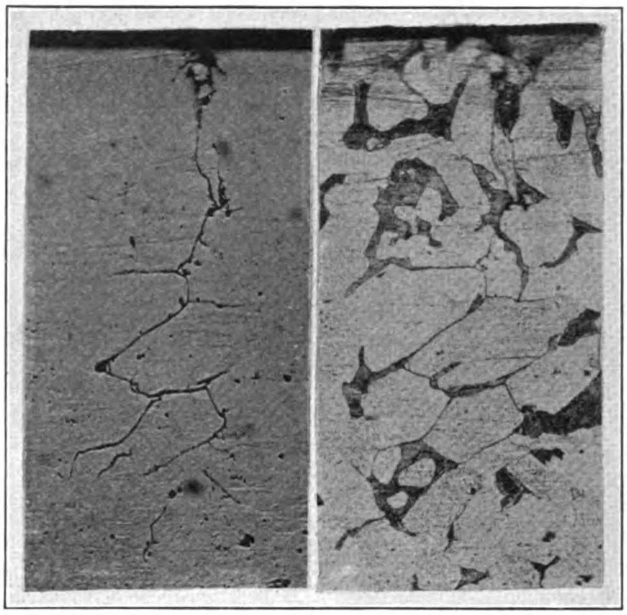

FIG. 10—Micrographs of boiler plate embrittled in tests. (Left)—Unetched. x 15. (Right)—Etched. x 150.

In addition it should be noted that during the fabrication of the boiler the seams are put together by riveting. The riveting is done hot and, granting that only sufficient riveting pressure is used to maintain tight seams, very high additional localized stress occurs under the rivet heads and around the rivet holes. When one observes the appearance of the plates and straps after they have been removed from a boiler which has been in service and notes the rings around the holes where the straps and plates have been held together by the rivets, there remains little doubt that the metal has locally, at least, been stressed beyond the yield point. When this stress is combined with the stress incident to operation of the boiler, additional local stresses develop which may still further favor embrittlement. The sharp angle which the rivet head makes with the shank combined with the stress forcing the rivet heads apart undoubtedly produces sufficient stress at this point to allow embrittlement to start. It is not uncommon to have rivet heads drop off embrittled boilers long before the plates are embrittled sufficiently to detect cracks. The stresses in plates caused by riveting were studied by R. Bauman,* and he showed that the plates are stressed locally to values exceeding the yield point even when low riveting pressures are used. H. F. Moore in his address before the American Society for Steel Treating in September, 1925, stated that there was no doubt of the existence of localized stresses which exceeded the yield point of the metal around the rivet holes in riveted sections.

(Continued on page 107)

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*"Forschungsarbeiten auf den Gebiete des Ingenieurewesens," Heft 252, 1922.

Unique Power House at Mystic Iron Works

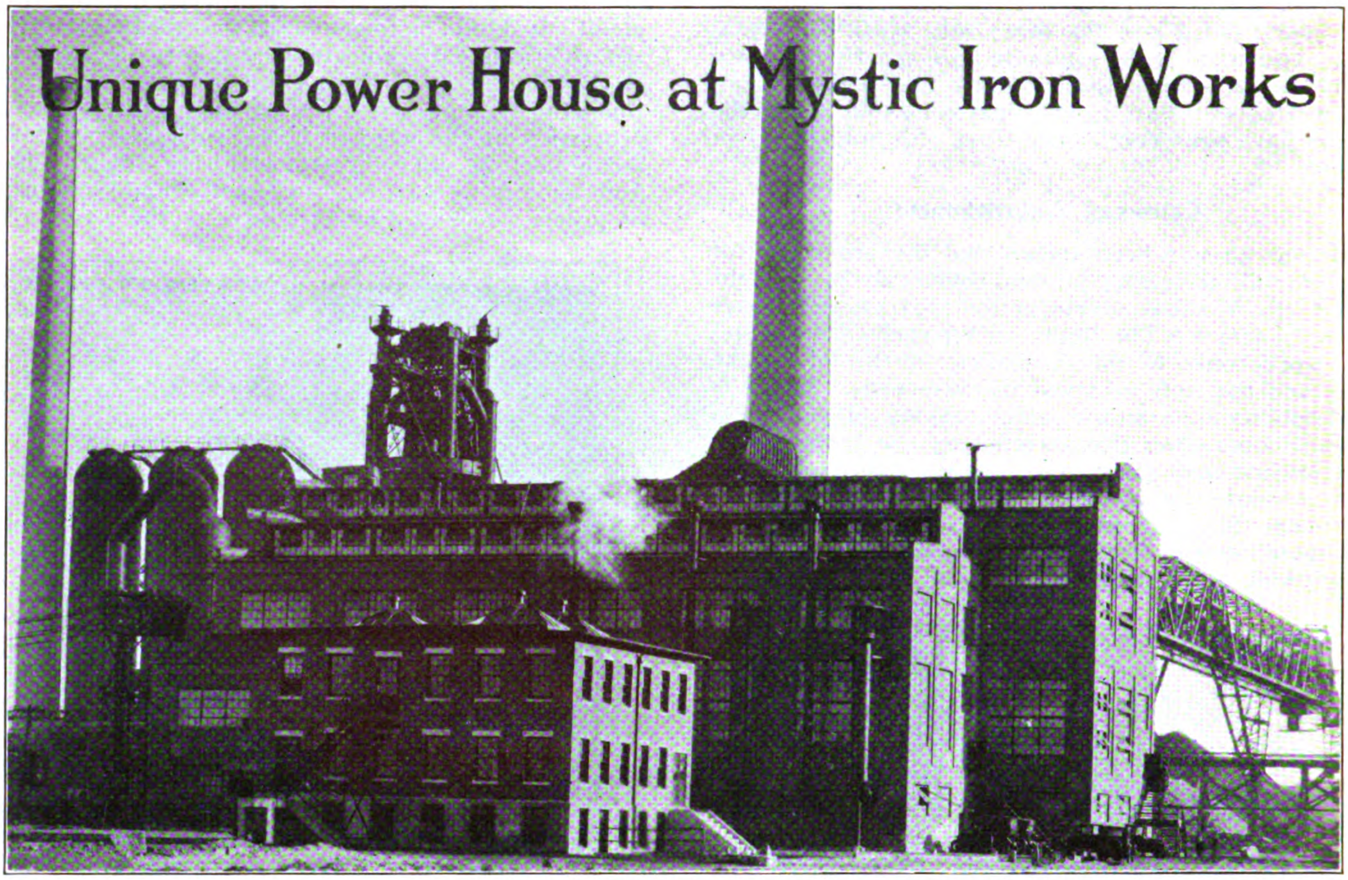

FIG. 1—Exterior of power house building.

Complete Layout of Blast Furnace Service Plant—Uses Three Kinds of Fuel—Condenser Water Used for Cooling Furnace—Installation of New Type Turbo-Blower

By ARTHUR J. WHITCOMB*

THE power station built as a part of the blast furnace plant of the Mystic Iron Works at Everett, Mass., was placed in operation in September, 1926. This power plant has several features giving it particular interest. It is a plant of moderate cost, yet affording economical operation. It uses by-product fuels, blast-furnace gas and coke breeze almost exclusively. It is the first installation of three-drum, three-pass boilers to be used on blast furnace gas and coke breeze. It is the first installation of a new design of General Electric blast furnace blowers. It employs an interesting system of water circulation.

The blast furnace plant which this power station serves utilizes by-product coke manufactured by the New England Fuel & Transportation Company, which supplies gas to much of the territory surrounding Boston. The plant is located on a part of upper Boston Harbor known as Mystic River. Iron ores from foreign sources are received by water. The little coal that is required for operation of the power plant is also shipped in by water from Virginia. The pig iron produced is sold in the local New England market.

The plant consists of a 450-ton blast furnace, the ore unloading and stocking equipment, the pigging and shipping department and the power plant. The power station not only supplies electric power and light, steam, wind and compressed air for the blast furnace plant, but also supplies steam for use at the adjacent coke plant of the New England Fuel & Transportation Company. A general view of the building, with the blast furnace in the background, is given in Fig. 1. The boiler house and turbine room are located in contiguous buildings as shown in Fig. 2, a floor plan being given in Fig. 8. As the entire plant was built on made ground and piling was necessary under all loads, a compact layout and one involving minimum cost for piling and site preparation was evolved.

New Type Water Tube Boilers

The steam required for power development and for servicing the blast furnace and the adjacent coke plant, is generated in six 814-hp., Erie City, three-drum, three-pass, water tube boilers. These boilers are of particular interest in that they are the first of a new type to be fired with blast furnace gas and coke breeze. These boilers differ from the usual three-drum installation in that an unusual circulation of water takes place in them. Feed water is admitted to the top rear drum as shown in Fig. 6, drops through the vertical tubes to the bottom drum, after which it circulates up through the lower inclined tubes to the front drum, returning to the bottom drum by the top

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*Assistant Electrical Engineer, Freyn Engineering Company, Chicago, Ill.

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inclined tubes. Steam is released above the water line in the front drum and by means of a baffle in this drum is forced through the bottom horizontal tubes connecting to the top rear drum and returns through the top horizontal tubes to the top part of the front drum above the baffle, whence it goes to the superheater. The result is that the steam is heated to a higher temperature than would otherwise be the case and hence dry steam is delivered to the superheater.

All of the boilers are arranged for two methods of firing. Three of them are equipped with Birkholz-Terbeck gas burners at the front end and chain grates for burning coke breeze at the rear end, as shown in the side elevation, Fig. 2. The other three are arranged with pressure combustion gas burners at the front end and grates arranged for hand firing of coal at the rear end. The chain grates are used primarily for burning coke breeze and the gas burners for burning blast furnace gas, these fuels usually being burned singly. Normal operation of the plant involves the burning of all surplus blast furnace gas and sufficient coke breeze to supply the steam demand. Coal is used only in emergencies when gas or coke breeze are not available in sufficient quantity to satisfy the load. The chain grate stokers are of particular interest in that they are of the forced blast, link type, instead of the more usual clip type chain grates. These were selected for the reason that lower maintenance cost is expected from them.

Concrete Stack Supplies Natural Draft

Natural draft is supplied to the boilers by a single concrete stack erected by The Heine Chimney Company, having a height of 225 ft. and an internal diameter at top, of 14 ft. Four fans, comprising two sets, are located in the basement of the boiler room as shown in Fig. 2. These supply the draft required in burning coke breeze on the chain grates and the air required by the pressure type gas burners used on the other three boilers.

Coke breeze and coal are delivered to the boiler house in hopper bottom cars. These fuels are hoisted by a skip hoist to a conveyor belt traveling over the fuel bins as shown in Figs. 2 and 8. Ashes drop into hoppers below the boilers and are delivered directly into standard hopper bottom railroad cars which run underneath the boilers. Although this is standard practice in many large public utility plants, it is somewhat unusual in connection with a blast furnace power plant and is justified by the large amount of supplementary solid fuel used.

Turbo-blowers Furnish Blast

In the turbine room are located two turbo blowers, two turbo-generators and an air compressor, as shown in Figs. 4 and 8. The blowers are of particular interest in that they are the first installation of the new General Electric design for blast furnace service. Each of the two units consists of a three-stage, water-

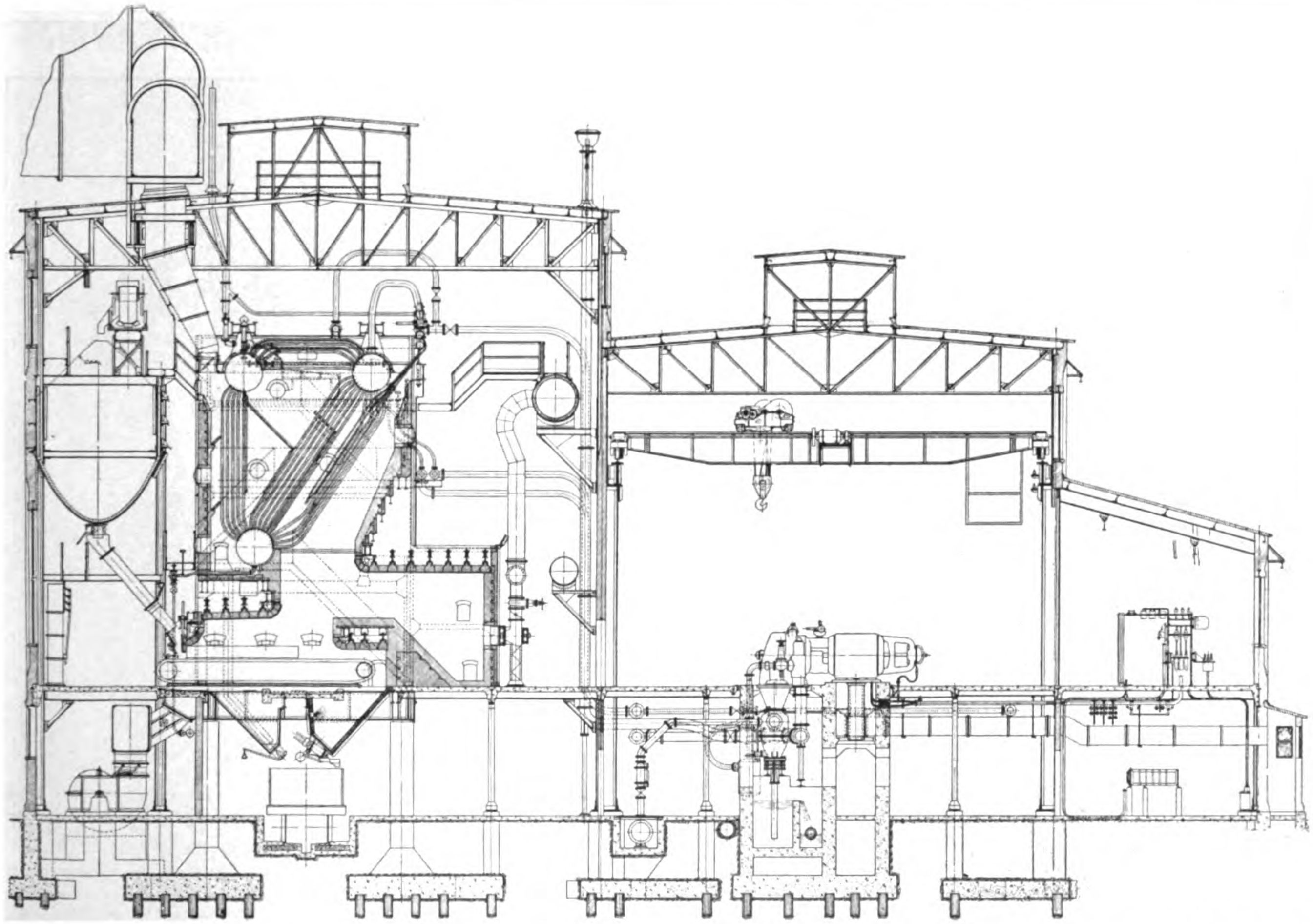

FIG. 2—Cross section elevation through boiler room, turbine room and electrical bay, showing combination stoker and gas-fired boilers as well as turbo-generator and bus structure.

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jacketed blower with radial flow impellers capable of delivering any volume up to 45,000 cu. ft. of air at pressures up to 30 lb. The drive turbines are eight-stage condensing, General Electric units with multiple valve control. Each turbine is equipped with the usual emergency and speed governors, the latter acting as a pre-emergency governor without shutting down the unit. In ordinary service, however, the blower is controlled by the new General Electric constant volume governor which responds to the drop across an orifice nozzle in the air intake line.

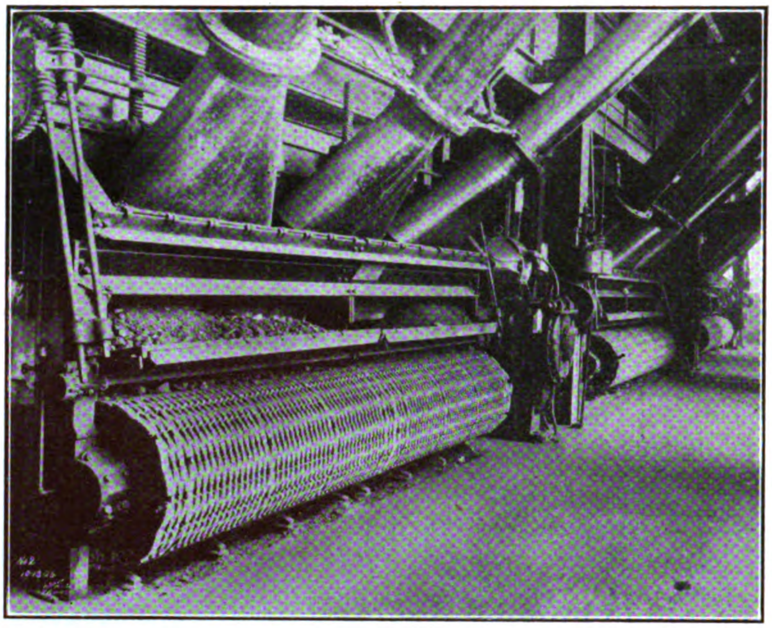


FIG. 3—Boilers are equipped to burn coke breeze, blast furnace gas or coal.

The heat balance of the plant is of some interest. Power development is but a minor factor in this plant. About half of the steam output is used at the coke ovens and a substantial portion of the rest is used for the blast furnace blowers and other services. In order to heat the boiler feed it was necessary to employ steam-driven auxiliaries extensively in addition to bleeding the generator turbines. Single-stage heating is employed, the generator turbines being arranged to maintain a suitable pressure for extraction to the feed water heaters.

Water Cooling Station

The water system is of particular interest. Brackish water from the Mystic River is used for general condensing and plant cooling purposes. The primary pumps are located at low-tide elevation in a depressed pump house adjacent to the river at some distance from the power plant. These pumps are all motor-driven. All of the water delivered by these pumps normally passes through Schutte-Koerting type condensers used on the blower and generator turbines. These condensers deliver to a well, shown in Fig. 5, which is located below the power house floor. From this well, water is taken for blast furnace uses. Turbine driven centrifugal pumps supply water to the

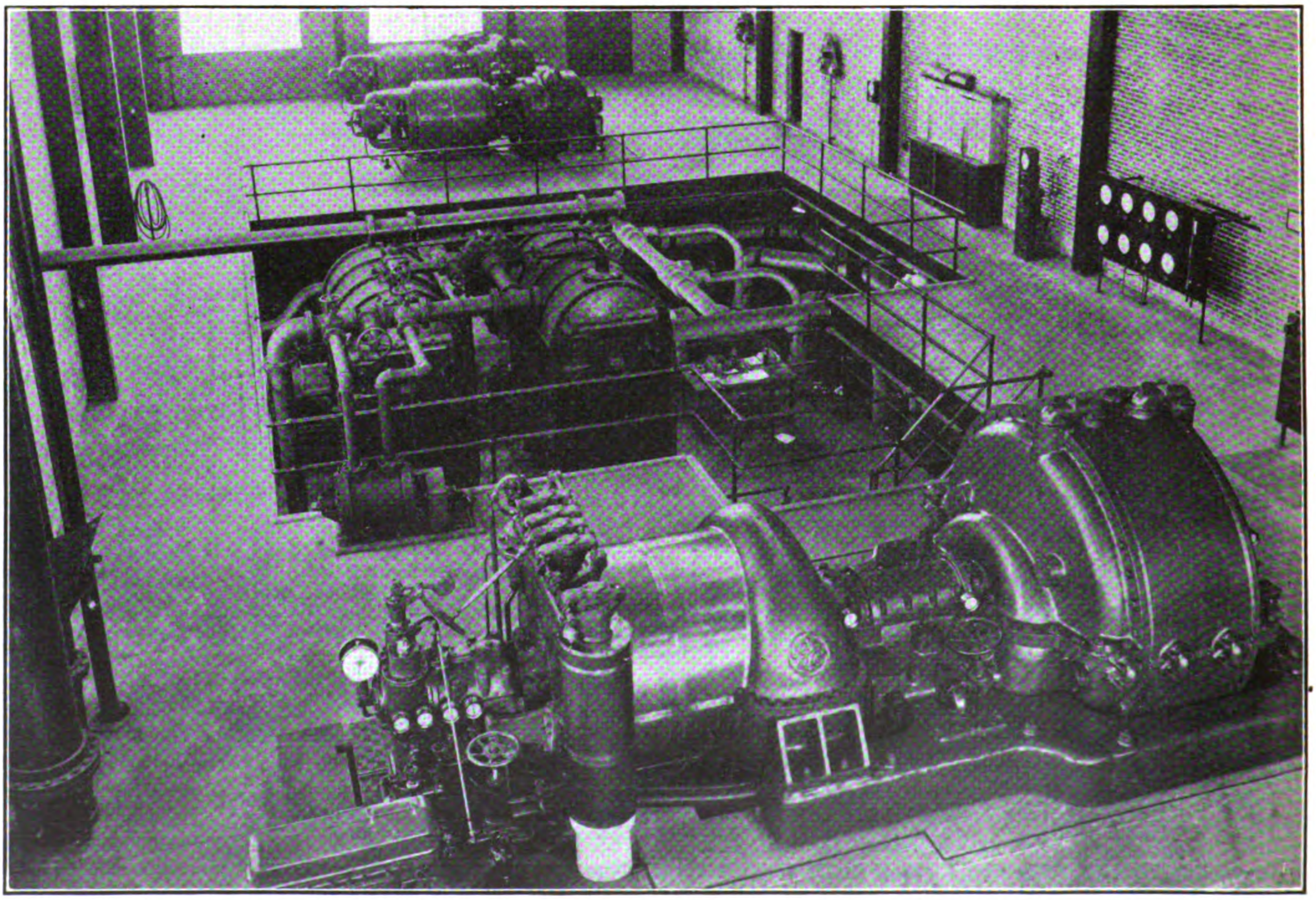


FIG. 4—Interior of turbine room showing turbo-generators, feed water heaters, and one of the two turbo-blowers.

gas washer, this water passing through a Dorr thickener and thence to sewer. Another set of centrifugal pumps supplies water to the blast furnace and stoves for cooling purposes. This cooling water is returned to the same well from which it was drawn, but at the opposite end from the intake, as is indicated in Fig. 5. At this end of the well there is a weir. In normal operation the water in the well is at such an elevation that the return water from the blast furnace and stoves flows over the weir and to the sewer. Should the primary water supply fail, the water level in the well will be lowered. Then the water returned from the blast furnace and stoves will not flow over the weir, but will be recirculated. An emergency make-up supply of water to this well can be taken from the city main.

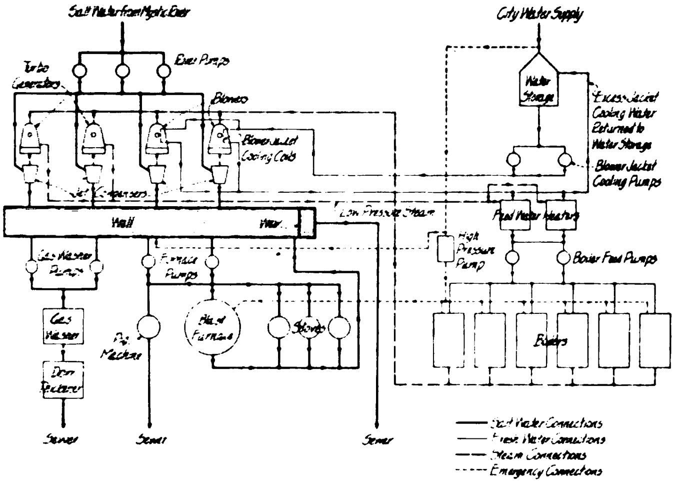


FIG. 5—Utilization of water supply at this plant is unique.

This water system permits the use of electrically driven primary pumps at the river pump house, yet it safeguards the important blast furnace cooling by means of automatic recirculation of cooling water by steam-driven pumps located in the power station. No elevated water storage is used. Incidentally, this system minimizes the total plant pumping power and restricts to the primary system the influence of a rather widely varying tide.

The boiler feed, which in any event would have to be largely make-up, is taken from the Everett city mains. This water is admitted to a storage reservoir adjacent to the power house. Water from this reservoir is pumped by small, duplex, steam pumps through the water jackets of the turbo blowers and thence to the open feed water heaters. Such portion of the jacket cooling water as is not required for the boiler feed is returned to the storage reservoir by the bypass shown in Fig. 5.

Electrical Equipment

The Electrical side of the power house has also been laid out with an idea of moderate cost yet good economy and utilization of the investment. Two turbo generator each rated at 750 kw. and two 500 kw. synchronous motor-generator sets are provided for. A major portion of the plant load is at 250 volts, d.c. One turbo-generator and one motor-generator set are sufficient to supply the load demands of the plant under normal operation when not unloading boats. When unloading boats with three unloaders and the ore bridge, the use of two-generators and both motor-generator sets is required, although unloading at reduced rate may be carried on with only one turbo-generator and one motor-generator in use. With this arrangement the essential functions of the plant are amply protected by duplicate equipment, yet the installation of a full capacity in spare apparatus, which would stand idle all of the time, is avoided.

The turbine generator units are rated at 750 kw., 3,600 rpm., and are provided with direct-connected exciters. Steam is supplied at 200 lb. gage and 125 deg. superheat. The turbines are three-stage, automatic extraction, condensing units. Extraction takes place at 2 lb. gage. As was previously mentioned, bleeding of steam from these turbines is required to heat the feed water supplementing the exhaust steam from the auxiliary drives.

Power Generated at 2300 Volts

Power is generated at 2,300 volts and is utilized at this voltage by the motor-generator sets, air compressor motor and river water supply pump motors. Transformers located in the lower level of the switch house provide 110-volt single phase for lighting. The bulk of the power requirement is d.c. and is supplied at 250 volts by the motor-generator sets.

The switchboard, as well as the motor-generator sets, are located in the switch house, which is adjacent to the power house and having common levels therewith. The motor-generator sets are carried on heavy steel beams with concrete ballasting and operate with no perceptible vibration. The switchboard comprises 14 panels, divided into an a.c. section of 7 panels and a d.c. section of 7 panels. The oil switches are of the remote mechanical control type and are mounted in a pipe structure in the rear of the switchboard with liberal aisles on both sides. Because of

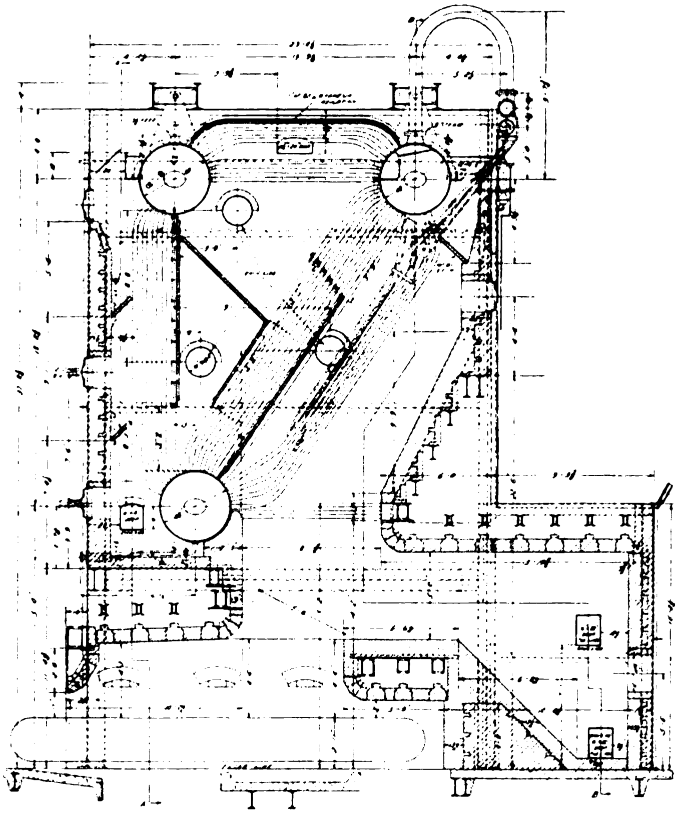


FIG. 6—Cross section of boilers showing the unusual arrangement of water flow through boilers.

Data on Power Plant Equipment used at Blast Furnace of Mystic Iron Works

GENERAL

Location of Plant—Everett, Mass.
Character of Service—Electric power, steam, wind, and compressed air for blast furnace and ore docks, as well as steam for adjacent coke plant of subsidiary company.
Elevation—Sea level.

General Dimensions:
- Boiler House—176 ft. by 60 ft.
- Turbine Room—132 ft. by 48 ft.
- Switch House—67 ft. by 21 ft.

BOILERS, SUPERHEATERS, STOKERS AND ACCESSORIES

Make of Boilers—Erie City Iron Wks.
Type—Three-drum, three-pass, water tube
Number Installed—Six.
Horsepower—Each, 814.
Boiler Pressure—225 lb. gage.
Water Heating Surface—Each, 8,145 sq. ft.
Steam Drying and Superheating Surface—Each, 820 sq. ft.
Maker of Superheater—The Superheater Co.
Superheat—125 deg. F.
Stokers—Harrington.
Number of Stokers—Three.
Maker of Furnace Arch—American Arch Co.
Gas Burners—Birkholz-Terbeck burners used on three boilers while remaining three boilers are equipped with Steinbart burners.
Soot Blowers—Diamond Power Specialty Co.
Fans for Gas Burners and Stokers—The Green Fuel Economizer Co.
Piping—Pittsburgh Valve, Foundry & Construction Co.
Fuel handling equipment—The C. O. Bartlett & Snow Co.
Ash Handling Equipment—Beaumont Manufacturing Co.
Feed Water Regulator—Copes.

CHIMNEY

Designed by The Heine Chimney Co.
Internal Diameter at Top—14 ft.
Height—225 ft.
Material—Concrete.

ELECTRICAL EQUIPMENT

Turbo-generators:
- Manufacturer—General Electric Co.
- Number Installed—Two.
- Capacity—Each, 750 kw.
- Power Factor—80 per cent.
- Speed—3,600 rpm.
- Characteristics—Three-phase, 60-cycle, 2,300-volt.
- Turbine Characteristics—Automatic extraction, condensing, 200-lb. gage, 125-deg. superheat, 1½-in. absolute back pressure.
- Exciters—Direct connected.

Motor-generator Sets:
- Manufacturer—General Electric Co.
- Number Installed—Two.
- Capacity—Each, 500 kw.
- A.C. Motor—700 kva., 900 rpm., 3-phase, 60 cycle, 2,300 volt, synchronous.
- D.C. Generator—250 volt, compound wound.

Switchboard:
- Maker—Condit Electric Mfg. Co.
- Panels—7 A.C. 2,300 volts; 7 D.C. 250 volts; 1 battery charging.

Transformers—Pittsburgh Transformer Co.

Condensers for Turbo-generators:
- Manufacturer—Schutte & Koerting Co.
- Number Installed—Four.
- Type—Multi-jet.

TURBO-BLOWERS

Manufacturer—General Electric Co.
Number Installed—Two.
Turbine Characteristics—Eight stage, 2,430/5,000 hp., condensing Curtis type.
Compressor Characteristics—32,000/45,000 cu. ft. free air per minute, 16/28.8 lbs. per sq. in., 3,700/4,750 rpm.

Condenser:
- Manufacturer—Schutte & Koerting Co.
- Type—Multi-jet.

AIR COMPRESSOR

Manufacturer—Ingersoll-Rand Co.
Type—Duplex.
Free Air Capacity—458 cu. ft. per min.
Final Air Pressure—100-lb. gage.
Driven by General Electric wound-rotor induction motor.
Rating of Motor—75 hp., 2,300 volt, 900 rpm.

FEED WATER HEATERS

Manufacturer—Worthington Pump & Machinery Corp.
Number Installed—Two.
Type—Horizontal, open.
Capacity—Each, 207,000 lbs. per hour.

BOILER FEED PUMPS

Manufacturer—A. S. Cameron Steam Pump Works.
Number Installed—Two.
Size and Type—5-in., three-stage, centrifugal.
Capacity—Each, 700 gal. per minute.
Governors—Fisher excess pressure.
Drive, Turbine—DeLaval Steam Turbine Co.
Horsepower—170.
Speed—2,050 rpm.

TURBO-BLOWER COOLING WATER PUMPS

Manufacturer—Worthington Pump & Machinery Corp.
Number Installed—Two.
Type and Size—10 x 10¼ x 12 in., horizontal, duplex, piston pattern.

RIVER PUMPS

Manufacturer—A. S. Cameron Steam Pump Works.
Number Installed—Three.
Type and Size—10-in., type FV, double suction, centrifugal.
Capacity—Each, 3,000 gal. per minute.
Drive, Motor—General Electric Co.
Number Installed—Three.
Type—Wound-rotor induction.
Horsepower—60.
Speed—1,200 rpm.
Voltage—2,300.

GAS WASHER PUMPS

Manufacturer—A. S. Cameron Steam Pump Works.
Number Installed—Two.
Type and Size—8-in., type LV, single stage, double suction, centrifugal.
Capacity—Each, 2,500 gal. per minute.
Drive, Turbine—DeLaval Steam Turbine Co.
Horsepower—170.
Speed—2,050 rpm.

FURNACE PUMPS

Manufacturer—A. S. Cameron Steam Pump Works.
Number Installed—Two.
Type and Size—10-in., type FV, centrifugal.
Capacity—Each, 4,000 gal. per minute.
Drive, Turbine—DeLaval Steam Turbine Co.
Horsepower—150.
Speed—1,750 rpm.

MISCELLANEOUS PUMPS

High-pressure Pump — Worthington Pump & Machinery Corp.
Number Installed—One.
Size—20 x 12 x 15 in.
Type—Horizontal duplex.

MISCELLANEOUS

Structural Steel—McClintic Marshall Co.
Crane—Cleveland Crane & Engineering Co.
Air Filter—Reed Air Filter Co.
Oil Filter—S. F. Bowser & Co., Inc.

the limited capacity of synchronous apparatus connected to the system, small oil switches and a simple structure could be used. However, the oil switches used have a liberal margin in rupturing capacity to provide for future growth or connection to a larger system.

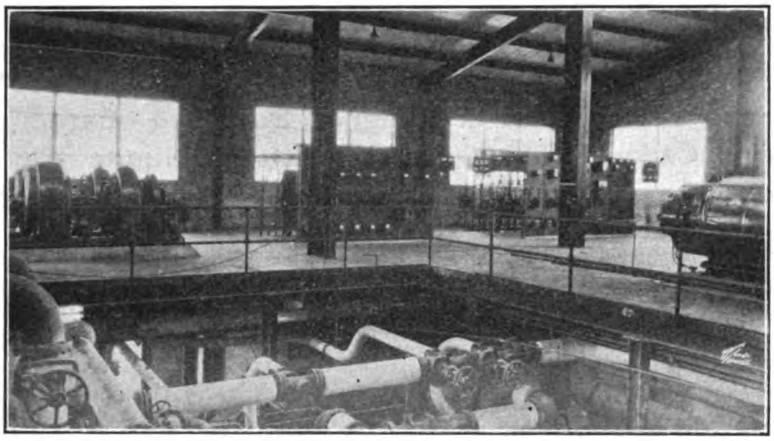


FIG. 7—Motor-generator sets and switching equipment are located in switch house adjacent to turbine room.

The switching arrangement includes a 12-volt, d.c., control bus which is supplied from a storage battery arranged with a Balkite trickle charger. The shunt trips on the oil switches, etc., are operated from this system and a few emergency lights are connected to it also. Inductive time element relays are used to protect feeder circuits while differential protection is used for the generators and their connecting leads. A voltage regulator of the Terrill type is provided, operating on the exciters, which are not paralleled.

This power station which is one of the most modern was designed and its construction supervised by Freyn Engineering Company, Chicago, as a part of the complete blast furnace project.

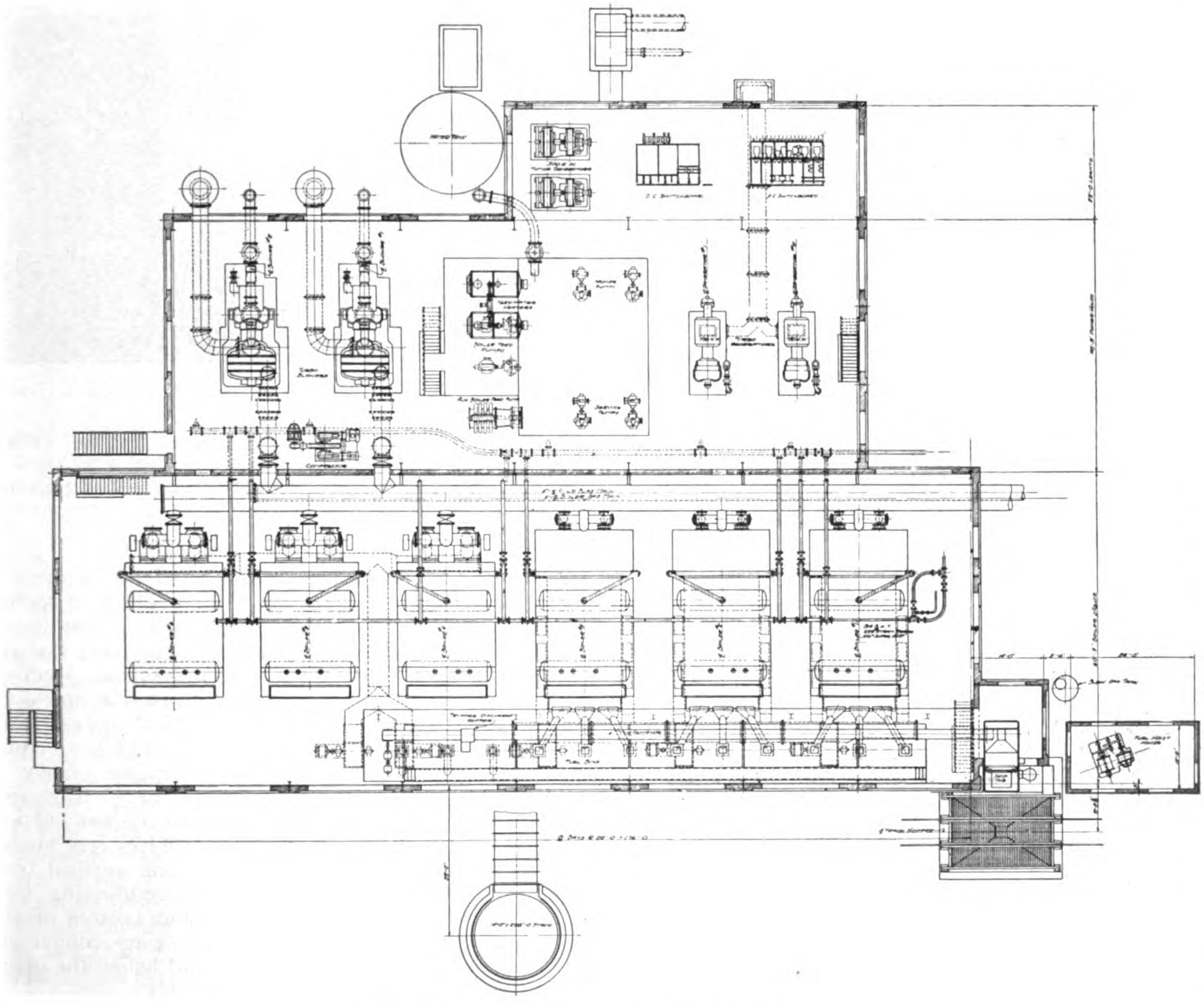


FIG. 8—General plan of complete power house.

Concrete Chimney of Large Dimensions

Design and Construction of Chimney Described—Capacity Sufficient to Carry Off 650,000 cu. ft. of Gas per Minute—Details Regarding Reinforcing and Concrete Mixing Presented

A CONCRETE chimney of exceptional height has been erected at the plant of the Wedge Roaster Plant of the Consolidated Mining & Smelting Company at Todanac, British Columbia. This chimney has a height of 400 ft. and diameter of 21 ft. inside the lining at the top. It was carried to this height not only to insure the required draft, to dispose of the gases from the zinc furnaces, but also to discharge these gases well above the ground line and eliminate any risk of injuring vegetation.

Before the gases reach the chimney, they are passed through a Cottrell dust collector so that the oxides and dust may be precipitated. As the quantity of gases may reach 650,000 cu. ft. per min., at an average temperature of 340 deg. F., it is apparent that ample draft must be provided, but the capacity of the chimney is such that the gases may vary in temperature from a minimum of 280 deg. F. to a maximum of 450 deg. F. It is estimated that the minimum temperature of the outside air will be 100 deg. F. while the variation in the content of SO will be from a trace to 2 per cent. Fig. 1 shows the chimney shortly after erection.

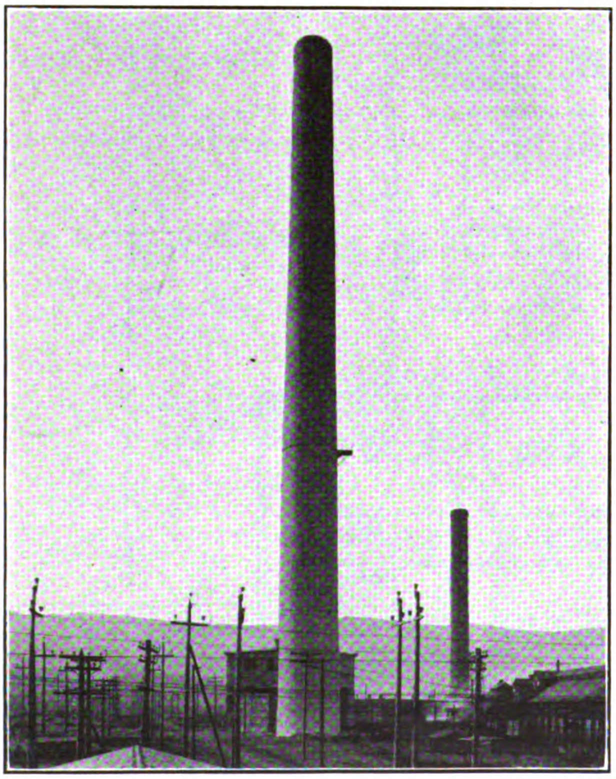


FIG. 1—View of finished chimney.

Twelve days after the contract had been signed the Rust Engineering Company, Pittsburgh, Pa., began field work, and within 170 working days, the erection had been completed in every detail. The concrete bars in place, ready for pouring concrete, are shown in Fig. 2.

The foundation which rests on sand and gravel is 66 ft. over the flats of the octagon and has a thickness of 9 ft. directly under the shaft, and contains about 900 cu. yds. of concrete. It required six days of 8-hour shifts to pour the concrete in this block. The base is heavily reinforced with square steel bars varying in size from ½ in. to ¾ in., while electric welded fabric is provided to take up the horizontal temperature stresses.

The equipment used in erecting the chimney is shown in Fig. 3. The wooden scaffolding was carried on the inside of the chimney to the full height and supports the cathead, which in turn was used to bear the weight of the forms and for the hoisting and distributing of the materials.

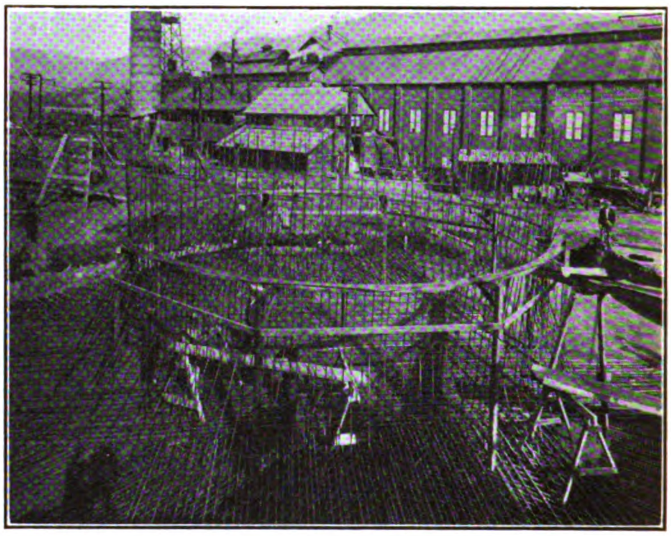


FIG. 2—Reinforcing at base of chimney.

Size of Flue Opening

A flue opening 32 ft. high by 13 ft. in width, extends above ground level 6 ft. 10 in. The first section of 45 ft. is circular on the inside, but is not truly circular on the outside. This is due to the fact that the walls of this section are not of a uniform thickness as it was necessary to provide additional concrete reinforcing at the flue opening. Here the thickness of the walls was increased to 9 in. at the outside, for a width of about 36 ft. and for a height of approximately 45 ft. That part of the chimney above the 45 ft. section conforms to true circle on both the inside and outside. Vertical reinforcing bars were inserted to take up the tension due to the wind load and the vertical temperature stresses, while additional reinforcing bars were placed at the side and top and bottom of the flue opening. At several points steel rings completely encircle the chimney, both above and below the openings. These are installed for stiffening purposes as well as to form a reinforced beam at the top and bottom.

The lining is of 4-in. vitrious acid-resisting brick supported on corbels on the inside of the shell of concrete. This brickwork is built in sections with a lead flashing at the top of each section while at the top of the chimney a lead cap covers the top section of the lining as well as the top wall of the main shaft.

Entrance to the chimney is obtained through a clean-out door built into the base while a ladder extends from the top of the flue opening to the top of the chimney. At an elevation of 160 ft. above the foundation an observation platform is located in order that the samples of the flue gases may be secured. The chimney is provided with a lightning rod made up of 10 points connected with a circuit cable and grounded by means of two down cables. The upper 50 ft. of the lightning rod is lead covered.

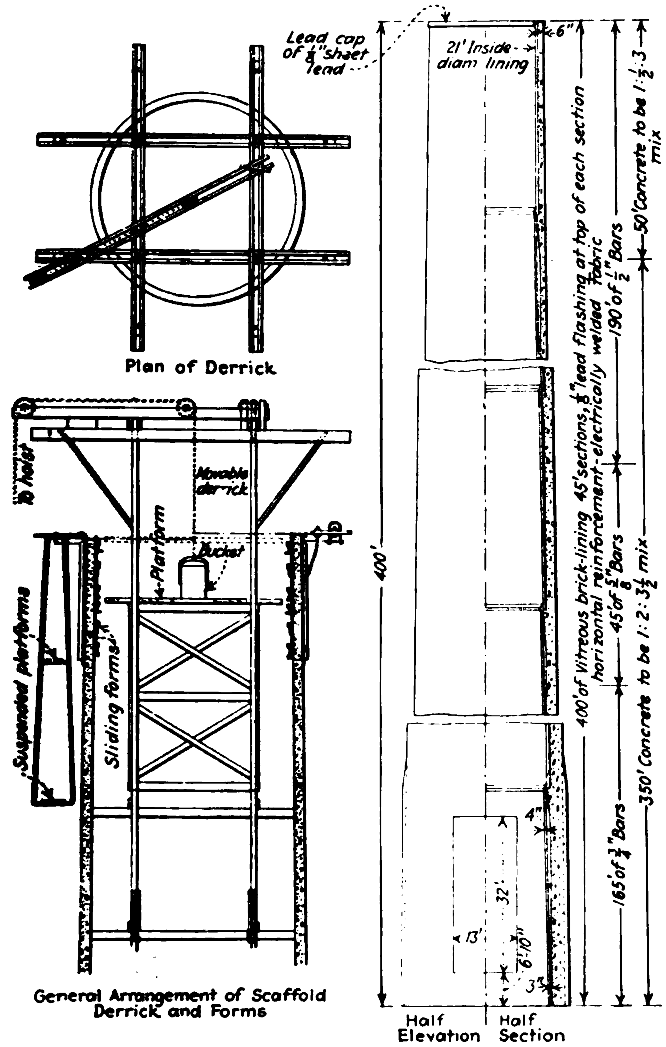

Plan of Derrick
To hoist
Movable derrick
Platform
Bucket
Suspended platforms
Sliding forms
General Arrangement of Scaffold Derrick and Forms
Lead cap of 1/8" sheet lead
21' Inside diam lining
6"
400'
400' of Vitreous brick-lining 45' sections, 1/8" lead flashing at top of each section
horizontal reinforcement-electrically welded fabric
190' of 1/2" Bars
45' of 5/8" Bars
165' of 3/4" Bars
50' Concrete to be 1:1½:3 mix
350' Concrete to be 1:2:3½ mix
4"
32'
13'
6'10"
3"
Half Elevation
Half Section

FIG. 3—Equipment used in erection.

For the foundation slab a concrete mixture was 1:2½:4½, and for the lower 350 ft. of the shaft was 1:2:3½. The course aggregate used in the shaft was screened ⅝ to 1¼ in. gravel. Great care had to be exercised in the construction of this chimney especially in locating the reinforcing bars. Likewise it was essential that the mixture of concrete be most uniform and that this mixture be poured in the correct manner.

All materials conform to the requirements of the standard specifications of the joint committee for reinforced concrete of the American Society of Civil Engineers.

The Embrittlement of Boiler Plate

(Continued from page 99)

This concentration of stresses exists in all boilers to a more or less degree, yet in the absence of the proper chemical in the boiler water no embrittlement results. If the proper chemical, sodium hydroxide, in the absence of much sulphates or carbonates exists in the boiler water there is a possibility that sooner or later that boiler will become embrittled. The concentration of sodium hydroxide in a boiler seldom surpasses 17,000 parts per million, about 1,000 grains per gallon. Laboratory tests show that solutions of this concentration are not detrimental to the steel. There is a possibility that the actual concentration of caustic soda in the vicinity of the seam does sometimes reach a value of 350,000 parts per million or about 20,000 grains per gallon. It is known that sodium hydroxide solutions of even such a low concentration as is met with in boiler operation can not readily be kept under pressure in containers with screw connections. Solutions of other salts can be retained, but with caustic soda leaks tend to develop. The presence of caustic under pressure in a boiler tends to produce a seepage of the solution into the seams between the metal surfaces. As the solution penetrates between the plates there is a tendency for it to become concentrated due to the steam being released back to the boiler or escaping to the outside. As the concentration progresses the penetration of the solution continues further into the seam. With time the concentration becomes sufficient to cause embrittlement, and, if localized stresses are sufficient at the point of concentration embrittling action begins. This concentration is often reached without embrittlement occurring, apparently due to the lack of sufficient stresses. In such cases the penetration progresses until a free leak develops, but on examination no presence of embrittlement can be found. In other cases embrittlement occurs, the plates are weakened, and a leak develops which indicates trouble. When the plates are removed from the seams of embrittled boilers soluble salts are found between the plates. This alone would indicate that there must have been considerable concentration in the seams. Evidence of chemical attack in the seams is given by the presence of finely-divided black magnetic oxide deposited on the surface of the plates.

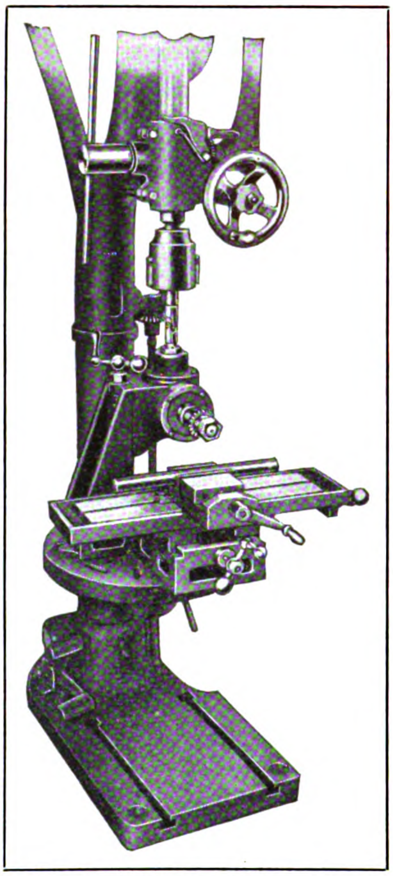
The fact that the two main factors responsible for embrittlement must occur simultaneously makes it possible for some boilers to be operated under conditions which might be expected to cause embrittlement without developing any distress. That no distress (apparent by general inspection) has occurred is no sign that the boiler is free from danger. An example of this is shown in the case of one installation operating on alkaline water. This plant had been in operation for over eight years and was cited as an example of a boiler operating on alkaline water and yet free from embrittlement. Six months later in this plant distress developed which turned out to be a very bad case of embrittlement. The engineer in charge has often since expressed wonder at the fact that one boiler in particular had not exploded, it was so badly cracked.

The real causes of embrittlement in steam boilers can be summarized, therefore, as concentration of caustic soda in the seams in the absence of much sulphate or carbonate, together with the existence of localized stresses in the seams.

NEW EQUIPMENT SECTION

Milling Attachment for Drill Presses

John W. Chapman & Company of Warsaw, Ind., has developed and just placed on the market the Hawkins Milling Attachment for Drill Presses, as shown in the accompanying illustration. In bringing out a machine of this type it is the manufacturer's idea to supply a small portable type milling machine, which will do precision work when required, and which will fill the place of the larger and heavier built floor type machines. In the design and construction of this machine same has been built with good ample bearing surfaces where required, so as to insure rigidity in the tool.


Drill press with milling attachment.

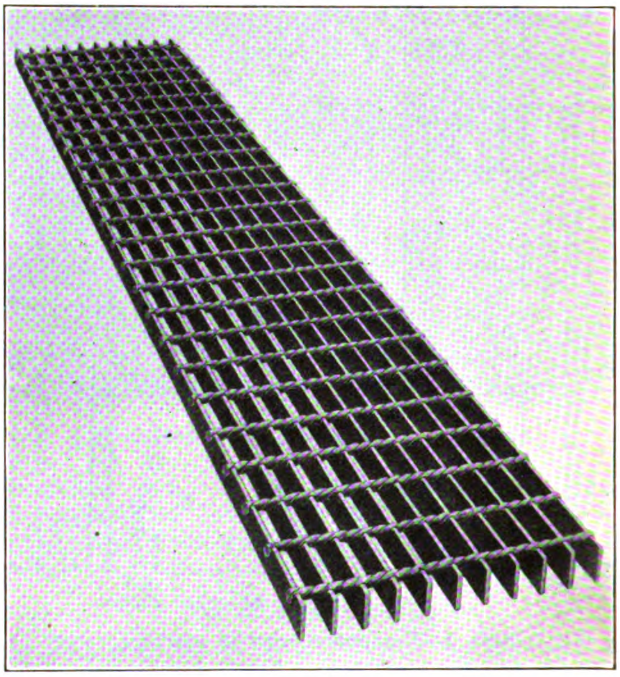
The milling attachment will convert a drill press into a milling machine, which when equipped will allow the performance of the 23 major milling operations coming under common machine shop practice today. In addition to the regular milling operations that this machine will perform, it can be equipped to do turning work, such as is done on a lathe, by mounting a three-jaw chuck on the spindle and fitting the table with a special tool holder for the cutting work. It can also be used for a cutting-off machine on bar stock, and can be used for light drilling, boring, and reaming operations.

The head, table, and spindle all have independent hand feed adjustment. The size table used on the plain type machine permits the use of various attachments, such dividing heads, universal angle plates, swivel vises, etc. This machine will use all standard milling cutters, and the spindle is equipped with a No. 9 Brown & Sharpe Taper. All the feed screws are equipped with micrometer dials, and all bearing surfaces are hand scraped to alignment. The spindle is driven through bevel gears, which are mounted in Shafer aligning taper roller bearings, and has a ratio of 1 to 1, so that the speed of the milling machine spindle is always the same as the drill press spindle, to which it is attached. The head is of the enclosed type, so that the gears are continually operating in oil.

This machine at the present time is built in two types, the plain type and the semi-universal type, and can be successfully operated on any upright floor type drill press 16 inches or larger. It is light enough in weight so that it can be easily handled in moving it from one part of the shop to the other. The total net weight being 140 pounds.

Blaw-Knox Security Grating

The Blaw-Knox Company, Pittsburgh, Pa., is manufacturing steel grating and flooring, of an entirely new design. This grating is called "Security Grating" because of the fact that this word so aptly fits its many original qualities. The full value of the metal is utilized without the use of bolts or slots, and it is strictly "non-slip" in every sense of the word.


Blaw-Knox security grating.

This grating represents a distinct departure in manufacturing methods from that of other gratings. It is made by means of a resistance welding process in which longitudinal bars and cross bars are welded into a one-piece construction.

These cross bars are slightly raised above the level of the longitudinal bars so that the foot is at all times in contact with the non-slip surface.

In this grating the longitudinal bars are crossed at right angles by twisted cross bars, a one-piece construction. There are no bulky joints, rivet heads, or any other unsightliness to conflict with the attractive appearance presented by this workmanlike product.

It is self-cleaning, as the cross bars mentioned are twisted in shape and placed at right angles to the longitudinal bars, thus forming no acute angles or pockets to catch dirt, dust, or other debris.

THE STEEL PLANT BRICK MASON

A Section Devoted to Items of General Interest to Blast Furnace and Steel Plant Brick Masons

Dr. M. L. Hartman has resigned as director of research of the Carborundum Company, Niagara Falls, N. Y., to become technical director of the Celite Products Company, Los Angeles.

* * *

Thomas Chalmers, recently made general superintendent of the coke plant, sheet and jobbing mills of the Tennessee Coal, Iron & Railroad Company at Fairfield, Ala., started to work for the company in 1907 as a bricklayer. He has been successively bricklayer foreman, assistant superintendent and superintendent of the coke plant.

The Refractory Question Box

The Blast Furnace and Steel Plant Brick Mason will be glad to answer questions of a practical nature on the use of refractory materials in general steel mill practice. Questions pertaining to any particular brand of refractory will not be answered.

Brick Mason,
The Blast Furnace and Steel Plant,
Pittsburgh, Pa.
Dear Sir:

What is Fire Clay, and what is the theory as to the manner of its original formation?

Yours very truly,
L. J. K.

Answer—Fire Clay can be considered an impure form of Kaolin (aluminum silicate) whose value depends upon its capacity to withstand high temperatures and which in turn is dependent upon the ratio of silica to alumina and the nature and amount of impurities contained.

The common varieties are more or less impure silicates of aluminum, formed by the decomposition or weathering of feldspathic rock, and contain high percentages of combined water. They may be residual or sedimentary. The most refractory clays are usually associated with the coal manner.

Brick Mason,
The Blast Furnace and Steel Plant,
Pittsburgh, Pa.
Dear Sir:

Allow me to congratulate you on your establishment of a department devoted to the problems of the steel plant brick mason. I sincerely believe that your innovation fills a very definite need, and that your progressive step will be appreciated by those who realize the importance of the subject of refractories maintenance in the steel and allied plants.

In the January "Refractory Question Box" I note a query from "C. N. B." as to the best practice for laying up clay brick and silica brick, but from my past experience I must say that I can not entirely agree with the answer that a mortar made of ground clay of the same composition as the brick gives the best results.

Such mortars as the afore-mentioned, or mixtures of fire clay and water as they are essentially, were in practically universal use from 20 to 25 years ago, because at that time no other material for laying up fire brick was known. While fire clay is still being used as a fire-brick bonding material in a good many plants today, it is falling into the discard because more and more plants are appreciating the importance of the bonding material in building furnace brickwork, and consequently turning to better materials for such uses.

Generally speaking, fire clay is a crude product as it comes from the mine and contains much natural moisture. When subjected to heat, this natural moisture, and any other water in the mortar evaporates, causing the joints between the fire bricks to shrink and crumble, whereupon they lose their bond and the fire clay falls out from the joints in the form of dust.

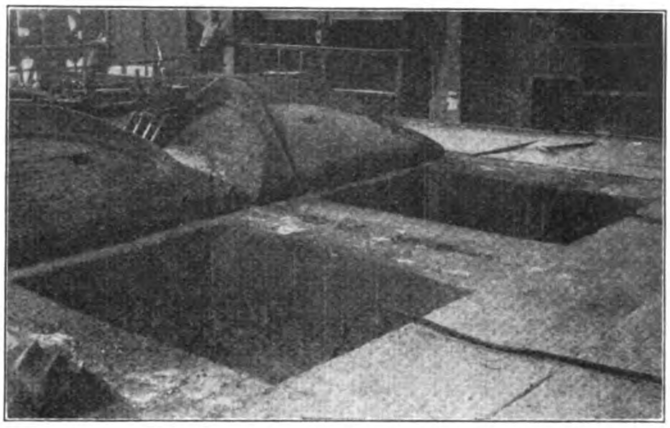


FIG. 1—Soaking pits and tops, the tops having several patches composed of crushed fire brick and high temperature cement.

It is generally conceded that the majority of furnace brickwork troubles originate at the joints between the fire brick. If the joints are not of sufficient strength and refractoriness, the life of the brickwork is shortened.

The writer is familiar with the methods employed in a number of steel plants for constructing and repairing firebrick construction, and most of these plants have entirely discarded the use of fire clay except where high temperatures are not encountered, and are using good high temperature cements in laying up and repairing brickwork.

High temperature cements cost a good deal more than fire clay, but when the additional cost for such cements is proved worth-while because high temperature cements have in a number of cases to my knowledge more than doubled—in some cases tripled—the service of brickwork, it is conceded that high temperature cements have earned their salt.

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A concern making steel castings may be cited as a typical case where the use of a high temperature cement in laying up the side walls of an electric melting furnace, and laying up the brickwork of electric annealing furnaces, electric core-oven and oil-fired drying ovens has proved highly efficient. They also paint the linings of their large and small ladles with a thin coat of this cement, thinned with water and used as a wash. Only with such material has this plant been able to obtain such long service as they now get from their various fire-brick construction.

In many ways a good high temperature cement is different from fire clay. A good high temperature cement enables the brick mason to get thin joints, which are acknowledged the superior form of building brickwork. A good high temperature cement will not shrink or crack in setting, nor will it open up under heat, nor through expansion and contraction caused by temperature changes, in which respects fire-clay mortar is diametrically opposite.

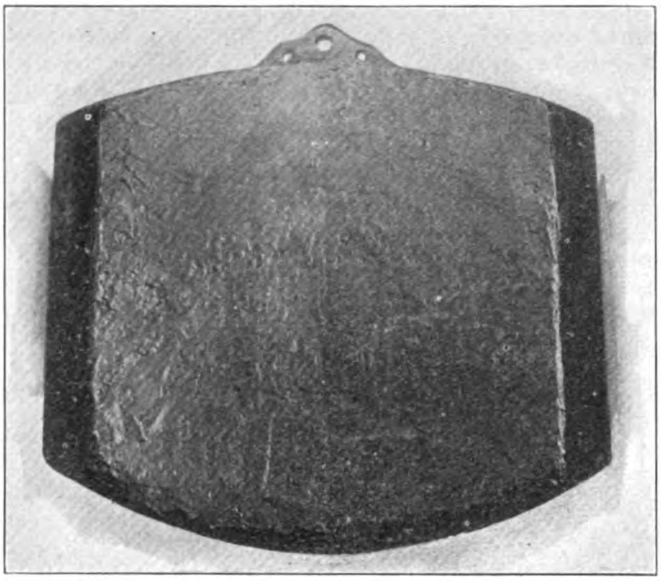


FIG. 2—A furnace door which is subject to high temperatures and furnace gases. The fire brick in this door were laid up with a high temperature cement, which eliminated loosening and falling out of the brick.

A good high temperature cement possesses a bond that is constant through the entire operating temperature range, from the setting temperature to the softening point of the highest grade fire brick, a property not found in any fire-clay mortar.

In addition to its use for laying up fire brick, high temperature cement can be used to advantage when thinned with water and used as a wash over the surfaces of brickwork that are exposed to flame. One or two thin coatings generally suffice, and they form a glaze under heat that protects the structure from corroding gases, the cutting action of flame, the penetration of carbon, the action of molten metals and other elements that shorten brickwork life.

A number of steel plants are utilizing a mixture of high temperature cement and chrome as a brush coating over brickwork where certain slag conditions exist.

Some of the same plants are using a high temperature cement as a binder for chrome for furnace bottoms and hot-patching in open hearths. Depending on the conditions existing, the mix of high temperature cement and chrome varies. Sometimes it is used in the proportion of one part of cement to six parts of chrome, varying up to equal parts of cement and chrome. Only trial and test will determine the mixture which will give the best service.

For patching burned-out sections of furnace linings, a mix of high temperature cement and crushed fire brick bats has proved wonderfully successful. Frequent inspection of furnace linings and repairs with this mix of cement and brick bats has prevented many costly furnace interruptions and has often deferred a complete re-lining.

Yours very truly

G. S. G.

TRADE NOTES

Inland Steel Company, has moved its St. Louis office from 504 to 508 Bank of Commerce Building, in charge of F. R. Meyer, Jr.

* * *

The United States Vanadium Corporation has been organized as a subsidiary of the Union Carbide & Carbon Corporation, 30 East Forty-second Street, New York, to take over the business of the United States Vanadium Company, a corporation of the state of Colorado.

* * *

The Utah Steel Corporation, Midvale, Utah, by purchase of its entire assets and obligations, has become the Western Steel Company, an organization recently formed for that purpose. The new company will continue to operate both the steel mills and waste material division of the old Utah corporation, and James J. Burke, receiver for the latter company, will be general manager under the new regime. The operating personnel of the company will not be changed.

* * *

The Wilson Foundry & Machine Company, Pontiac, Mich., is advancing production at its plant and in the past fortnight close to 800 men have been added to the pay roll, making a working force of approximately 2600. It is planned to continue the expansion until close to 4000 men are employed, scheduled by the end of January. That increase is due to heavy orders from the Willys-Overland Company, Toledo, with which the Wilson Company is affiliated.

* * *

The Standard Seamless Tube Company of Pittsburgh has recently contracted with the Chapman-Stein Furnace Company of Mt. Vernon, Ohio, for two continuous recuperative reheating furnaces for their bar mill at Ambridge, Pa. These two furnaces will be end charge, side discharge type and will be used for reheating blooms of approximately 10 in. x 10 in. x 12 ft. 9 in. long. Each furnace will be designed for a normal capacity of 25 tons of steel per hour, heated from cold to rolling temperature. Each furnace will have an approximate overall length of 72 ft.

* * *

Improvements under way at the Indiana Rolling Mill Company, New Castle, Ind., include the addition of one 3-ton electric furnace which will produce approximately 40 tons of high-carbon, soft-center and alloy steels in 24 hours. The company also is removing a steam engine which operated four mills, and is substituting two 300-kw. motors. A steam generator also is being replaced by a 300-kw. generator, using current purchased from an outside source.

PERSONALS

J. B. Marks, vice president in charge of sales, traffic and purchases of the Colorado Fuel & Iron Company, Denver, and assistant to J. F. Welborn, president, was recently elected executive vice president of the company. Mr. Marks will have supervision over all departments of the company's activities.

* * *

Alfred Crook, formerly vice president and general manager of the Tioga Steel & Iron Company and the Philadelphia Roll & Machine Company, Philadelphia, will represent the Pittsburgh Rolls Corporation, Pittsburgh, in the East, with his offices in the Widener Building, Philadelphia.

* * *

Ellis M. Johnston, resigned his position as president and treasurer of the American Tube & Stamping Company recently taken over as the American Tube & Stamping division of the Stanley Works.

* * *

F. A. Estep, for many years president and treasurer of the R. D. Nuttall Company, Pittsburgh, manufacturer of gears, and subsidiary of the Westinghouse Electric & Mfg. Company, East Pittsburgh, Pa., has been made chairman of the board.

* * *

E. M. Herr, president of the Westinghouse company, became president of the Nuttall organization and Milton Rupper, vice president, assumed the duties also of treasurer. F. A. Merrick is first vice president and James C. Bennett, secretary.

* * *

A. W. Griffith, assistant general superintendent in the Youngstown district for the Carnegie Steel Company, Pittsburgh, has retired on account of ill health.

* * *

William D. Evans and J. C. Watson have been elected directors of the Jones & Laughlin Steel Corporation, Pittsburgh. Mr. Evans is general counsel and Mr. Watson treasurer of the corporation.

* * *

Walter S. Fischley has been transferred to the Detroit office of the Youngstown Sheet & Tube Company, Youngstown, Ohio.

* * *

Dr. F. C. Langenberg, director of laboratories at the Watertown Arsenal, Watertown, N. Y., has become associated with the Climax Molybdenum Company, New York, as head of its research department.

* * *

John F. McConnell, formerly with the United Alloy Steel Corporation, Canton, Ohio, as vice president in charge of operations, and later with the Donner Steel Company, Inc., Buffalo, in an advisory and consulting capacity, has been appointed vice president in charge of operations of the Penn Seaboard Steel Corporation, Philadelphia. Mr. McConnell at one time was vice president of the Interstate Iron & Steel Company.

* * *

C. E. McGregor, formerly associated with the Republic Flow Meters Company, Chicago, has joined the sales force of the Brown Instrument Company, Philadelphia, and will handle sales of the company's new electric flow meter in the Chicago territory.

* * *

Peter J. Connell, for 46 years a blooming mill roller at the Ohio Works of the Carnegie Steel Company, Youngstown, retired last week, and will be placed on the pension list. He rolled the first ingot that passed through the rolls at the blooming mills of the Ohio works, 32 years ago.

* * *

Harvey M. Rein has resigned as Youngstown District representative of the Mesta Machine Company to accept a position in the sales department of the Aetna-Standard Enginering Company, which is a combination of the Aetna Foundry & Machine Company of Warren, Ohio, and the Standard Engineering Company of Ellwood City, Pa. Mr. Rein was previously associated with the United Engineering & Foundry Company and the Youngstown Foundry & Machine Company.

* * *

B. H. Lytle has been appointed as manager of Hyatt Roller Bearing Company, Newark, N. J., with headquarters at 806 Fulton Building, Pittsburgh, Pa. This appointment places Mr. Lytle in charge of the sale of Hyatt Roller Bearings for all applications in the Central Division, except automotive.

* * *

Fred Hughes Moyer has been elected as vice president of Mackintosh-Hemphill Company, and will give particular attention to the sales and engineering departments. Mr. Moyer is a man of unusual experience in connection with general steel works practice, and has been intimately associated with the industry since his graduation from Cornell in 1899. His earlier training was received under Mr. E. E. Slick, former chief engineer of Carnegie Steel Company. He has contributed to the engineering development of some of the most notable steel plants in this country including Clairton Plant, Carnegie Steel Company; Gary Plant, Indiana Steel Company, and Cambria Steel Company, in the capacity of chief engineer, as well as in operating capacities with Pittsburgh Crucible Steel Company and United Alloy Steel Corporation.

OBITUARIES

Walter W. Cox, 52 years old, of the W. W. Cox Company, St. Louis, metallurgist and analytical chemist, died suddenly at his home there January 4. He was formerly with the Bethlehem Steel Company, and later was connected as metallurgist and chemist with several of the large iron and steel interests.

* * *

Frank I. Ellis, consulting engineer, aged 63 years, died January 16, in the West Penn Hospital, Pittsburgh. He was born and educated at Melbourne, Australia, came to the United States as a young man, and was associated for some time with Julian Kennedy, consulting engineer, Pittsburgh. Mr. Ellis was later employed in the Pittsburgh mills of the Carnegie Steel Company and afterward became chief engineer for the Frank Kneeland Machine Company. Leaving that company in 1913 when it became a part of the United Engineering & Foundry Company, he was made general manager of the Mark Manufacturing Company, Zanesville, Ohio. Two years later he entered private practice as a consulting engineer.

* * *

William H. Hodgins, Secretary of The Okonite Company, died after a brief illness on January 7 at his home in Glen Ridge, N. J. Mr. Hodgins had been associated with The Okonite Company for over 40 years, and served for many years as a director in addition to his office as secretary.

TRADE PUBLICATIONS

Alloy Steel—Central Alloy Steel Corporation, Massillon, Ohio, has published a booklet under the title, "The Story of Alloy Steel," which contains much information as to the development of this class of steels and its adaptation to various uses. Data show the increase of alloy steel use and illustrations of units of the company's plants to embellish it.

* * *

Power Plant Equipment—Hills-McCanna Company, Chicago, has issued a booklet covering its line of force feed lubricators, discussing the matter of lubrication and illustrating its devices in detail. Full information is provided in engineering data and specifications. The company's line of chemical proportioning pumps is also shown.

* * *

Pyrometers—Bristol Company, Waterbury, Conn., has issued a pamphlet describing its pyrometers and core oven recording thermometer. The pyrometers are of wall or portable type, and the fire end of the thermocouple for obtaining temperatures of non-ferrous metals has two separate wires which may be replaced without disturbing the remainder of the couple. The metal bath forms the junction between the wire elements.

* * *

Limit Stops and Compensators—Electric Controller & Mfg. Company, Cleveland, has issued two bulletins dealing with limit stops for alternating and direct current motors on cranes or other power driven machines which must be automatically stopped, and compensators for squirrel-cage and synchronous motors.

* * *

Air Washers—Mellish-Hayward Company, Chicago, is distributing a bulletin describing construction and giving specifications for its air washers for use in heating and ventilating systems. Illustrations and diagrams explain the principle on which the washer operates, its installation and care. Details of the washer are shown and considerable data on conditioning of air.

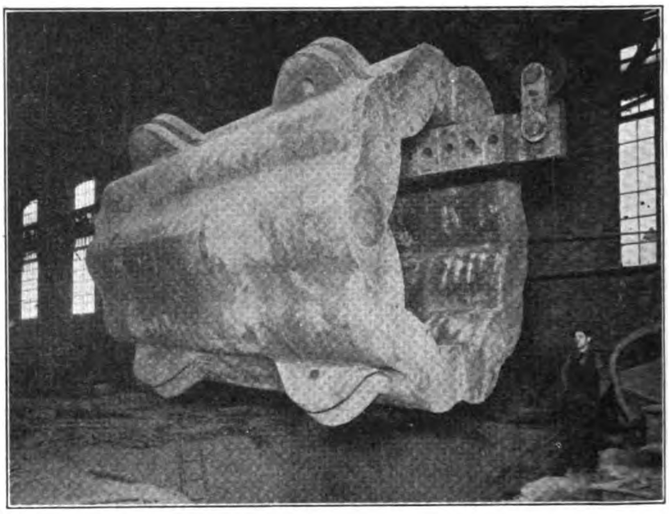
Correction

An item appearing on page 480 of the November issue of The Blast Furnace and Steel plant under the heading "Huge Motor and Reduction Gear in Spanish Steel Mill" contains the statement that the plate mill was built by the Mackintosh-Hemphill Company, Pittsburgh.

We wish to correct this statement. The major portion of the mechanical equipment of the plate mill, together with combined blooming and slabbing mill, rail mills, and the continuous merchant mills, were supplied by John Musgrave & Sons, Ltd., Bolton, Eng.

Large Ingot Mold Cast by Bethlehem

Bethlehem Steel Company, at its Bethlehem, Pa., plant, has just completed and put into service an extraordinarily large ingot mold for casting ingots which will be used in making large forgings.



This casting, as poured, weighed 387,590 pounds, with a finished weight, after cleaning and removal of sinkhead, of 382,000 pounds, or 191 tons. The length of the casting is 15 ft. 6 in., with a width of 108 in. measured across the corrugations at the top of the mold, and 97 in. across the concave portions of corrugations. The ingot produced from this mold will weigh, with sinkhead, 247 tons.

Iron Ore in Mexico and Central America

(Continued from page 76)

Up to the present time there has been practically no iron ore mined in Mexico or Central America, but the reserve tonnage in these countries will justify further exploration and expense and in the future these countries should become exporters of iron ore as in all probability the domestic demand will not support a large iron industry.

IRON ORE RESERVES OF MEXICO AND CENTRAL AMERICA

Country	Reserve
Mexico	500,000,000
Honduras	10,000,000*
Nicaragua	25,000,000
Panama	25,000,000*
Total	560,000,000

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*Estimated.

The Blast Furnace and Steel Plant

Member of the Audit Bureau of Circulations

PITTSBURGH, PA., FEBRUARY, 1927

Entered as second class mail matter at Pittsburgh, Pa., under the act of Congress, March 3, 1879.

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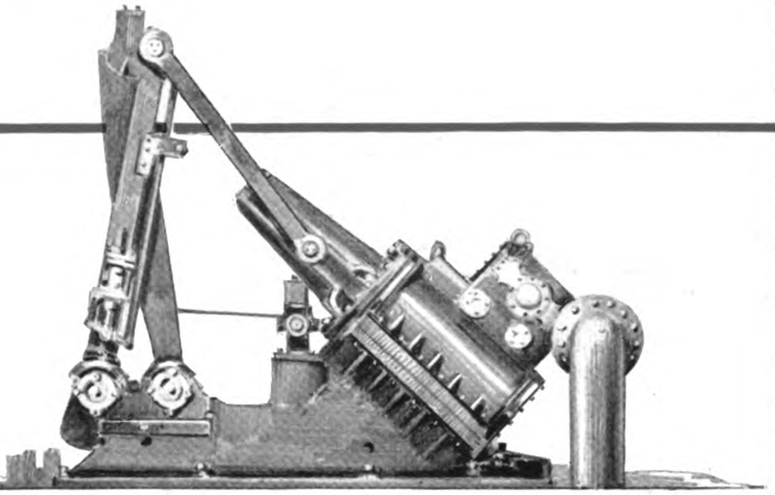

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